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A National Environmental/Energy Workforce Assessment. Post-Secondary Education Profile: Radiation

National Field Research Center, Inc, Iowa City, IA

Prepared for

Environmental Protection Agency, Washington, DC

Dec 78

PB 291186

Post Secondary Education Profile

RADIATION

Phase II
Of A National Environmental/Energy Workforce Assessment

Conducted by:

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16. ABSTRACT
This study is one of 16 volumes aggregating data on representative environmental education offerings in the United States at post-secondary education institutions and in the private sector of the economy. Structured around on-site interviews, the study describes the institutions' education programs — their program structure, representative course offerings, faculty structure, and program requirements. In addition, the study provides information on the employment history of graduates.

Designed as Phase II of a three-phase program, the study presents the information on schools in the following volumes: two volumes on potable water and two on wastewater; one volume each on air, noise, pesticides, radiation, solid waste and energy; a two-volume composite report on environmental engineering/health; a one-volume report on education/ecology; and a volume on some training programs conducted by businesses and by trade and professional associations. In addition, the study includes a one-volume abstract and a one-volume summary. The study is an overview. It doesn't include all environmental programs in the United States, and it makes no attempt to evaluate the program offerings.

Phase I of the study assessed the workforce needs (manpower needs) for pollution control and abatement in the United States for the five-year period of 1976 through 1981. Phase III, which will be available in September 1979, will offer recommendations, curriculum changes, and modifications that appear necessary to assure a properly trained national environmental workforce

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Air Pollution Water Pollution Solid Wastes Potable Water Pesticides Radiation Noise Pollution Energy Manpower Environmental Engineering Environmental Health Environmental Education Environmental Protection Pollution Control Instruction Schools Education Ecology	National Environmental/Energy Workforce Assessment	

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NATIONAL ENVIRONMENTAL/ENERGY WORKFORCE ASSESSMENT

PHASE II

POST-SECONDARY EDUCATION PROFILE

RADIATION

Conducted by:

NATIONAL FIELD RESEARCH CENTER, INC.

Under Grant from:

UNITED STATES

ENVIRONMENTAL PROTECTION AGENCY

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INTRODUCTORY NOTE

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Sincere appreciation is expressed to those persons within the United States Environmental Protection Agency, Office of Federal Activities, who provided guidance and direction throughout the term of the project: Mr. J. Donald Cook, Project officer; Mr. Joseph McCabe, and Mr. Michael Moore. Special thanks are also extended to Mr. Tahlman Krumm, Ohio State University.

Gratitude must be expressed to the many individuals and organizations from the private sector who were most generous in their contribution to this project. Their openness and responsiveness reflect their concern regarding the training of our environmental workforce and their critical role in that effort.

REVIEW COMMITTEE

A special word of acknowledgement is extended to the following people who graciously gave of their time, knowledge and experience in order to review and comment on the information included in this volume. The efforts of this national committee were particularly insightful, and in general have been incorporated into the final report.

It must be pointed out that in all cases the individuals acknowledged below were asked only to review and comment on the material contained in the volume and to express their views regarding the representativeness of the material presented. They were not asked to endorse either the volume or the study in general, and the inclusion of their name on this list should not be considered an endorsement since such was not the intent.

In light of numerous responsibilities, it is especially important to note that these persons responded within very strict time constraints. Such a pattern reflects positively on both the individuals and the institutions and organizations which they represent.

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FOREWORD

Information for this report was largely compiled from on-site interviews with professionals in post-secondary institutions throughout the United States. On-site interviews were supplemented by telephone and/or mail contact to clarify and revalidate the data. This report presents a summary of programs in junior colleges, vocational/technical training institutes, community colleges, four-year colleges, and universities as well as other training institutions. Programs are representative of all levels from academic certification through doctoral degrees. The environmental pollution control areas of air, noise, pesticides, potable water, radiation, solid waste, wastewater and energy were surveyed.

This study was conducted for the United States Environmental Protection Agency by the National Field Research Center, Inc. of Iowa City, Iowa, with field offices located in Atlanta, Georgia; Denver, Colorado; and Washington, D.C.

NATIONAL ENVIRONMENTAL/ENERGY WORKFORCE ASSESSMENT

PHASE II

POST-SECONDARY EDUCATION PROFILE

RADIATION
SUMMARY

RADIATION

A. STATES, INSTITUTIONS, PROGRAMS AND DEGREES

Examined in Phase II of the National Environmental/Energy Workforce Assessment were twenty-five academic radiation training programs which are located in fourteen states. Training programs contacted ranged from certificate level programs offered by such institutions as Memphis State University and the Oak Ridge Associated Universities, to advanced degree programs offered by engineering, public health and science oriented schools. It was not possible to contact all radiation training programs by colleges and universities but the study attempted to include a representative sampling of the radiation training programs which are now being offered to students at academic institutions. Most (15) of the institutions contacted offered multiple degrees and whenever possible,descriptions included information on all degree levels.

The following table depicts the number of programs surveyed by degree:

RADIATION DEGREES, PROGRAMS AND STATES

Degree	Number of Programs	States Visited
Certificate	2	Connecticut Florida
Associate	6	Georgia Kansas
Masters	2	Maryland

RADIATION DEGREES, PROGRAMS AND STATES (cont'd)

Degree	Number of Programs	States Visited
Multiple Degree Programs:		Massachusetts
Associate/Bachelors	1	Michigan
Associate/Bachelors/ Masters/Ph.D.	1	Missouri
Bachelors/Masters	1	New Jersey
Bachelors/Masters/Ph.D.	6	New York
Masters/Ph.D.	6	North Carolina
		Oklahoma
		Pennsylvania
TOTAL	25	Tennessee

B. ENROLLMENT STATISTICS AND GRADUATES

A wide variety of recruitment techniques are employed by academic institutions to attract prospective students to their programs. Twenty-two programs provided information describing thirty-seven different types of recruitment techniques that they employ. Nine programs did not consider it necessary to recruit students because their programs are well known in this field and consequently they receive more applications than they can accept. Many of the others sent recruitment information packets to inquiring students and to undergraduate programs and high schools. Others relied principally upon high school and community college visitations.

Mostly in-state students are enrolled in Associate and Bachelors degree programs and including foreign students, at the Masters degree level, out-of-state students predominate in radiation enrollments. Radiation programs with long-standing reputations such as at Rensselaer or Rutgers, for example, tend to attract a greater number of out-of-state and foreign students for advanced degrees. Graduate students are attracted by the financial aid and the research facilities offered by graduate programs in radiation training.

Of twenty-seven programs responding to requests for information on graduate follow-up, twenty (74%) had some method of following up where their students were obtaining employment. Newsletters, mail surveys and alumni meetings were the means most often employed to keep current graduate lists.

The following table describes the enrollment profiles combined of all of the programs included in the survey:

RADIATION ENROLLMENT PROFILE SUMMARY

Degree	Enrollment Full-time	Enrollment Part-time	Graduates Average # Per Year	Enrollment Change by Program Up	Down	Stable
Associate	299	44	131	2	3	3
Bachelors	680	9	148	3	0	5
Masters	401	101	181	9	0	8
Doctoral	119	24	55	3	1	7
TOTAL	1499	178	515	17	4	23

C. FACULTY

A total of 207 full and part-time faculty members serve the twenty-seven radiation training programs described in this volume. Approximately

72 percent, or 160, are full-time and twenty-eight percent, or 63, are part-time. In many of the programs, a variety of departments supply faculty to teach occasional specialty courses from time to time.

Most faculty members consider sponsored research projects to be an excellent way to stay current with the changing techniques and technology in this field. Most are members of professional associations and attend meetings and conferences which are held. Occasional consulting activities are also considered to be an excellent way to stay current in this field and to stay cognizant with changing applications of techniques to solve problems which arise in everyday activities of the nuclear power industry.

D. CURRICULA

At the associate level, students are introduced in many of the programs described in this volume to principles of health physics, instrumentation and other aspects of applied engineering technologies. Nuclear technicians are principally concerned with the detection, measurement and analysis of sources of both ionizing and non-ionizing radiation. Baccalaureate students in this field of engineering or science are directly concerned with the release, control and safe utilization of nuclear energy. Undergraduate programs are normally intended to prepare students for industrial employment, government service and graduate study. Advanced degree candidates are provided greater opportunities for study involving fundamental research, industrial applications, and community health aspects of radiation protection. Graduate students may specialize in radiation protection topics which involve radiation effects in materials, reactor safety, radioactive waste management, and environmental measurement. Applied study terms are a very active and integral (though not usually required) part of many of the radiation training programs. Summer internships are occasionally also offered at such places as Brookhaven National Laboratory at Long Island, New York. In the radiation area, 14 of the 27 (52%) programs offer work-study.

Forty degree programs were asked for information concerning the flexibility of how courses and programs can be changed. Included are responses from fifteen (63%) of the twenty-four institutions contacted. Of forty degree programs, seventeen (43%) said that it took between one month to one year to implement course content changes, and between one to two years to implement content changes in a program.

E. RESEARCH FUNDING AND SOURCES OF STUDENT FINANCIAL SUPPORT

The radiation programs included in this study receive a diversity of funding and the most common sources are the Department of Energy (Energy Research and Development Administration and the Nuclear Regulatory Commission), the National Science Foundation, and the Electric Power Research Institute.

Students receive support from federal grant and loan programs, graduate teaching and research assistantships, training grants, internships and other forms of employemnt, and other sources to assist them in defraying their educational expenses. Graduate teaching and research assistantships were most often cited as the major financial assistance source by nine programs (39%). Internship and co-op programs are utilized by seven institutions (30%).

F. EMPLOYMENT

The following table depicts employment data of graduates from the twenty-five institutions visited that offer degrees in the radiation field. Figures were provided by faculty members and were often estimates or based on results of formal follow-up studies.

RADIATION EMPLOYMENT PROFILE - NATIONAL

Degree	Private Sector				
	Industry	Consulting	Combined	Government	Other
Associate	27	6	33	65	2
Bachelors	42	11	53	28	19
Masters	28	10	39	30	31
Doctoral	17	10	27	31	42

Faculty of the institutions contacted were asked to provide occupational information indicating those which they felt their graduates were qualified to fill. The occupations most often cited were:

Degree Level	Occupations
Associate	Health Physics Monitor, Health Physics Technician, Radiologist Technician.
Bachelor	Radiological Health Specialist, Radiation Physicist, Radiation Inspector, Nuclear Instrumentation/Control Technician.
Masters	Radiation Biophysicist, Health Physics Monitor, Medical Radiation Physicist, Radiation Engineer, Radiological Health Specialist.
Doctoral	Medical Radiation Physicist, Radiation Physicist, Radiological Health Specialist.

PROJECT BACKGROUND

Photo reprinted from the University of Wisconsin, Madison Oceanography and Limnology Catalog

PROJECT BACKGROUND

OVERVIEW:

In late 1975, Congress acknowledged the growing national concern for the preservation and conservation of our national resources with a direct inquiry into the availability and readiness of our environmental workforce. That inquiry has taken the form of a three-year, three-phase National Environmental/Energy Workforce Assessment, currently being conducted by National Field Research Center under the direction of the U.S. Environmental Protection Agency. In keeping with the objective of the assessment, this three-phase national effort directs itself at environmental/energy workforce needs, national educational preparedness, and the functional relationship between the two.

PHASE I:

Phase I of the National Environmental/Energy Workforce Assessment focused upon the development of "workforce demand projections" through 1982 for all public environmental agencies. This on-site assessment, which was carried out in all 50 states, Puerto Rico and the Virgin Islands, culminated in a numerical profile of the growth patterns and workforce needs at the national and state levels. Stratification of the overall definition of "environmental occupation" into seven distinct vocational areas enhanced even further the applicability of the results. In addition to this public sector workforce assessment, Phase I included an overview analysis of private sector needs (through an adjunct mail survey of selected businesses and industries) and a brief review of selected environmental educational programs.

Phase I was completed in May, 1977. The 70-volume final report included:

* National Abstract	(1)
* National Legislation	(1)
* Regional Assessments	(10)
* State Assessments (including D.C., VI and PR)	(53)
* Business and Industry Assessment	(1)
* National Summary	(4)

PHASE II:

Phase II of the National Environmental/Energy Workforce Assessment was structured around an intensive on-site inventory of representative environmental educational offerings on a national scale. The primary objective of this project has been to collect and aggregate data on training and educational programs in both the post-secondary education field and in the private sector and to do so by environmental area. Specifically, the study was designed to provide an overview of environmentally related post-secondary education programs, their program structure, representative course offerings, employment history of the graduates, and the faculty structure. Additionally, information was to be collected on program requirements and program projections.

Initially, opportunities to nominate programs for inclusion in this on-site review process was given to the Environmental Protection Agency and its program officers and regional personnel both through the

Project Officer and via direct mail requests; all state departments of education; state environmental agencies and selected media-specific associations. These nominations were supplemented by a direct review of institutional catalogs, information obtained during the first year's on-site activities, and a review of other published sources of information regarding degree programs in environmental areas. These sources are included in Appendix III - Selected Bibliography.

Following their initial development, the lists of nominees were forwarded to the program officers for suggestions regarding additions or deletions. Next, letters were written to those nominated institutions seeking their support and cooperation in the on-site review process. Several programs, some of which were highly recommended, declined the opportunity to participate giving reasons varying from lack of time to the fact that the program being inquired about no longer existed, to outright refusal to cooperate with any government study. These institutions were deleted from the final on-site process. The remainder were included in the study and are shown in Table 1 of each volume. Selection of the sample for the private sector is discussed in depth in that particular volume.

In preparation for the on-site interviews, appropriate persons were contacted in the institution involved and were given a background description of the study, a suggested timetable for the interview process and were told what kind of information was being sought. This was all done in an effort to keep the time involvement of the individual contact persons at a minimum. During the actual on-site interview, generally lasting around one hour, the information was collected, questions asked and answered, and further informational contacts identified. Following this process, each on-site interview was written up in the form of a Training Program Summary, which where time allowed, was returned to the contact person for critiquing prior to inclusion in the report.

Throughout this process, individuals and institutions were given assurance that this study was not an attempt to evaluate program offerings and every attempt has been made on the part of the writers to live up to this assurance. Inclusion in this report provides no assurances of quality, nor should a program's exclusion be consideration of the lack thereof. In many instances certain programs within an institution were not included while others were, primarily due to the determination of the sample - previously discussed. This too should not be viewed in any qualitative manner.

REPORT ORGANIZATION:

The final report, of which this volume is a part, consists of volumes depicting a training profile in each medium under consideration, namely,

Air
Energy
Noise
Pesticides
Potable Water
Radiation
Solid Waste
Wastewater
Composite
Business and Industry and Trade Associations

At the outset it should be pointed out that there are very few degree programs conveying degrees in a particular medium; rather, degrees are offered in various specialties which lend themselves to obtaining employment in one or more of these fields. Nonetheless, to obtain maximum utility for the funding agency, programs were reported in this fashion. The Composite section was necessitated by the number of programs offering course work in multiple fields and differing specializations resulting from course selection. For convenience in handling of the data Potable Water, Wastewater and Composite have been reported in multiple volumes because of the numbers involved. Although separated into volumes either by degree level of the programs involved, as in the case of Potable Water and Wastewater, or by content as in the case of Composite, persons interested in any of these fields would be well advised to review each of the volumes to assure more complete coverage.

Along with the standard introductory pages common to volumes of this nature, each volume contains sections on Project Background, Introduction (consisting of sections devoted to a description of the programs surveyed and covered in the volume), Project Commentary, and the Training Summaries along with the Appendices.

REVIEW PROCESS:

In addition to individual training summary reviews conducted by the persons initially interviewed, each volume has been reviewed internally, by persons in the Environmental Protection Agency and by a select group of review committee members. In the final instance, individuals met during the on-site process were nominated by interviewers for inclusion on the review committee, primarily as a result of their obvious expertise in the field and their evidenced interest in the project.

These persons were then contacted by mail or by telephone in an effort to determine their willingness to serve. The rather stringent timelines necessary to keep the project on course and to deliver the finished product as specified were also detailed. In excess of one hundred persons returned their volumes (out of a mailing of 120) and all but five of these provided usable responses. In these five instances either last minute job demands prevented them from carrying out the review in the short timelines, or (in two instances) individuals indicated that they wanted nothing to do with the process. This particular method of review provided a wealth of valuable information, suggestions for revision of specific elements, and general comments helpful in revising the final documents. In all cases an effort was made to seriously consider and incorporate reviewer suggestions. The persons on the various review committees are individually acknowledged in the front of the volume they reviewed.

Photo reprinted from the University of Missouri, Columbia Bulletin 1977.

INTRODUCTION

Photo reprinted from the Northland College Catalog 1975-76

INTRODUCTION

This report describes Radiation training programs offered by 25 academic institutions. Included are Memphis State University and the Oak Ridge Associated Universities which offer specialized training for continuing education and certificates. Although the report attempts to concentrate mainly on radiation protection curricula, aspects of technologies, engineering, and public health were included. Because we chose not to concentrate on advanced degree programs to the exclusion of other education levels, not all possible programs were included in our survey.

Descriptions of eight Associate degree programs are included in this report. Analyzed were programs in nuclear engineering technology, radiological health technology, nuclear safety, radiological technology, engineering technology, and nuclear technology. At the associate level, students are introduced in many of these programs to principles of health physics, instrumentation and other aspects of applied engineering technologies. Nuclear technicians assist professional engineers in radiation safety, reactor operations, radionuclide handling, nuclear and control instrumentation, fuel fabrication, and health physics. They are principally concerned with the detection, measurement and analysis of sources of both ionizing and non-ionizing radiation.

At the baccalaureate level, students usually receive instruction in those fields of engineering or science which are directly concerned with the release, control, and safe utilization of nuclear energy. Included are programs in nuclear engineering, radiation biophysics, radiological science, and engineering technology. Programs are available which prepare individuals broadly in the design, development, and control of nuclear systems as applied to the use of radiation in medicine, environmental sciences, energy production, and related areas. Undergraduate programs are normally intended to prepare students for industrial employment, government service, and graduate study.

Graduate programs were included in the areas of radiological sciences, nuclear engineering, radiation biophysics, environmental health sciences, radiological health and radiological hygiene. Advanced degree candidates are provided greater opportunities for study involving fundamental research, industrial applications, and community health aspects of radiation protection. Areas of emphasis include medical and biological uses of radiation and radioactive materials, reactor thermal hydraulics, reliability and safety, and applied physics. Graduate students may specialize in radiation protection topics which involve radiation effects in materials, reactor safety, radioactive waste management, and environmental measurement.

For a complete listing of all Radiation programs, see Appendix I.

TABLE I

PARTICIPATING INSTITUTIONS

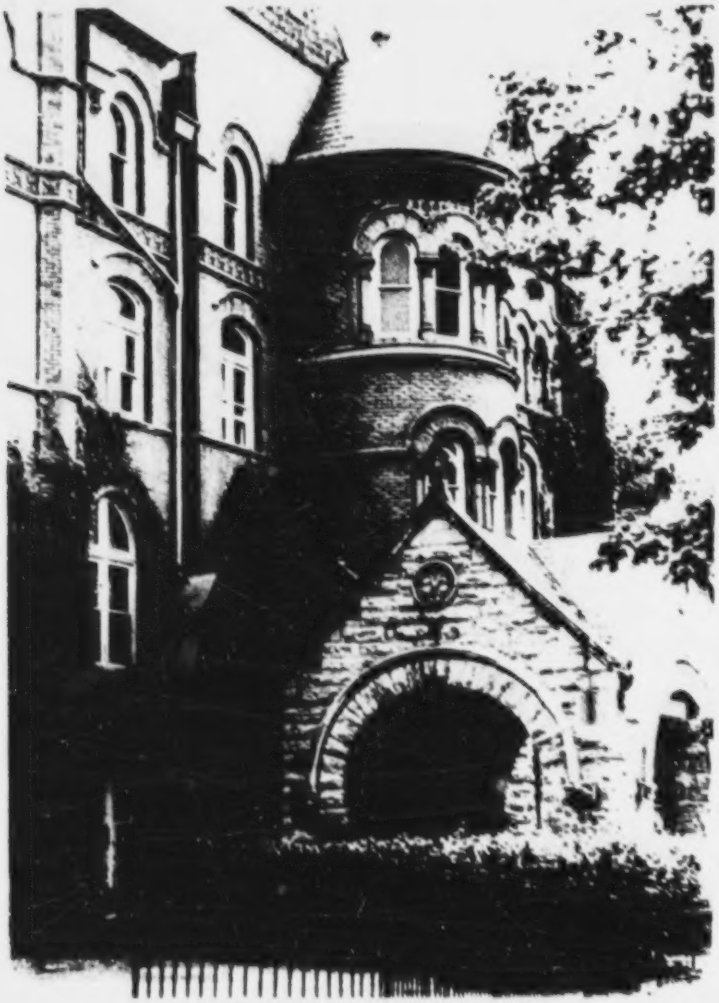

Photo reprinted from the Macalester College
1976-78 Catalog

Table 1 is a comprehensive listing of all institutions which participated in the post-secondary educational profile of the National Environmental/Energy Workforce Assessment. Listed by state, institution, and degree are programs surveyed in the areas of air, energy, noise, pesticides, potable water, radiation, solid waste and wastewater.

An explanation of the degree abbreviations utilized within the report may be found in Appendix I, entitled "Degree Abbreviations". For a complete listing of the institutions visited in a media specific area (i.e., air, energy, etc.), attention is drawn to Appendix IV, entitled "Participating Institutions by Environmental Category".

The Table in part III of the Project Findings, entitled "A Summary Profile of Representative Educational Programs" follows the narrative and is a presentation of specific institutions visited for the particular volume.

TABLE I

PARTICIPATING INSTITUTIONS

STATE	INSTITUTION	PROGRAM TITLE	DEGREE(S)*
AL	University of Alabama University	Environmental Engineering	M.S. (3)
AK	University of Alaska Fairbanks	Environmental Quality Engineering Science	M.S.
AR	University of Arkansas Fayetteville	Agricultural Engineering	B.S. M.S. Ph.D.
		Civil Engineering	M.S.C.E.
		Environmental Engineering	M.S.En.E.
		Environmental Science	B.S.
CA	California Institute of Technology Pasadena	Environmental Engineering Science	M.S. Ph.D.
	California Polytechnic State University San Luis Obispo	Environmental Engineering	B.S.
	California State University-Sacramento Sacramento	Civil and Environmental Engineering	B.S. M.S.
	Stanford University Stanford	Environmental and Water Studies	M.S. Ph.D.
	University of California-Berkeley Berkeley	Nuclear Engineering	B.S. M.S. M.E. Ph.D. D.E.
		Pest Management	B.S.
		Sanitary Engineering	M.S. M.E. Ph.D.
	University of California-Davis Davis	Environmental Toxicology	B.S.
		Plant Protection and Pest Management	M.S.

TABLE I

PARTICIPATING INSTITUTIONS

STATE	INSTITUTION	PROGRAM TITLE	DEGREE(S)
	University of California-Davis (Cont'd)	Entomology	B.S. M.S. Ph.D.
	University of California-Riverside Riverside	Pest Management	M.S.
	University of California-Santa Barbara Santa Barbara	Environmental Studies	B.A.
CO	Colorado State University Fort Collins	Environmental Engineering (Civil)	M.S. Ph.D.
	Community College of Denver-Red Rocks Golden	Water-Wastewater Technology	A.A.
CT	Hartford State Technical College Hartford	Nuclear Engineering Technology	A.S.
	Yale University New Haven	Environmental Health	M.P.H.
DE	Delaware Technical and Community College Newark	Environmental Engineering Technology	A.A.S.
	University of Delaware Newark	Entomology and Applied Ecology	B.S.
		Environmental Engineering	M.A.S. M.E. Ph.D.(App. Science) Ph.D.(ChE)
DC	Catholic University Washington	Civil Engineering	B.S.
	Howard University	Environmental Engineering	M.E.

TABLE I

PARTICIPATING INSTITUTIONS

STATE	INSTITUTION	PROGRAM TITLE	DEGREE(S)
FL	Broward Community College Fort Lauderdale	Pest Control Technology	A.S.
	Central Florida Community College Ocala	Radiological Health Technology	A.S.
	Florida International University Miami	Environmental Studies	B.A. B.S.
		Environmental Engineering Technology	B.S.
	Heed University Hollywood	Ocean and Environmental Affairs	M.A. Ph.D.
	Miami-Dade Community College Miami	Environmental Engineering Technology	A.S.
		Marine Science Technology	A.S.
	University of Florida Gainesville	Air Pollution	M.E. M.S. Engineer Ph.D.
		Environmental Biology	M.E. M.S. Engineer Ph.D.
		Environmental Resources Management Activities	M.E. M.S. Engineer Ph.D.
		Systems Ecology	M.E. M.S. Engineer Ph.D.

TABLE I

PARTICIPATING INSTITUTIONS

STATE	INSTITUTION	PROGRAM TITLE	DEGREE(S)
	University of Florida (Cont'd)	Water Supply and Water Pollution Control	M.E. M.S. Engineer Ph.D.
		Nuclear Engineering	B.S.(N.E.) B.S.E.(N.E.) M.E. M.S. Engineer Ph.D.
		Radiological Sciences	M.E. M.S.
	University of Miami Miami	Marine and Atmospheric Science	M.S. Ph.D.
GA	Abraham Baldwin Agricultural College Tifton	Plant Protection	A.Ag.
	Atlanta University Center/ Georgia Institute of Technology Atlanta	Water Pollution Control Design Engineering	B.S. B.E.
	Georgia Institute of Technology Atlanta	Acoustical Engineering	Advanced Cert.
		Energy Engineering	Advanced Cert.
		Environmental Studies	Advanced Cert.
	Southern Technical Institute Marietta	Nuclear Safety	A.S.
	University of Georgia Athens	Entomology	B.S. A.B. M.S. M.P.P.P.M. Ph.D.

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STATE	INSTITUTION	PROGRAM TITLE	DEGREE(S)
	University of Georgia (Cont'd)	Environmental Health Science	B.S.E.H.
HI	University of Hawaii Honolulu	Environmental and Sanitary Engineering	M.S.
IL	Illinois Institute of Technology Chicago	Environmental Engineering	B.S.E.S. M.S. Ph.D.
	Prairie State Community College Chicago Heights	Air, Water, Wastewater	A.A.S.
	Sangamon State University Springfield	Environments and People	B.A. M.A.
	Southern Illinois University-Edwardsville Edwardsville	Wastewater Treatment Operator Training	Cert.
IN	Indiana University Bloomington	Environmental Programs	Cert. A.S. B.A. B.S. M.P.A. M.S.E.S. Ph.D. (minor)
	Purdue University West Lafayette	Environmental Sciences Option	B.S.
		Nuclear Engineering	B.S.N.E. M.S. Ph.D.
IA	Iowa State University Ames	Environmental Studies	B.A. B.S.
		Sanitary Engineering and Water Resources	M.S. Ph.D.

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STATE	INSTITUTION	PROGRAM TITLE	DEGREE(S)
	Kirkwood Community College Cedar Rapids	Environmental Health Assistant	Diploma
		Environmental Health Technician	A.A.
		Water and Wastewater	Diploma
	University of Iowa Iowa City	Environmental Engineering	M.S. Ph.D.
		Environmental Toxicology	M.S. Ph.D.
KS	Kansas State University Manhattan	Chemical Engineering	B.S. M.S. Ph.D.
		Mechanical Engineering	B.S. M.S. Ph.D.
		Nuclear Engineering	B.S. M.S. Ph.D.
		Sanitary Engineering	M.S.C.E.
	University of Kansas Lawrence	Environmental Health Engineering	M.S. Ph.D.
		Environmental Health Science	M.S. Ph.D.
		Environmental Studies	B.A.
		Radiation Biophysics	B.A. B.S. M.S. Ph.D.
		Water Resources Engineering and Science	M.S. Ph.D.

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PARTICIPATING INSTITUTIONS

STATE	INSTITUTION	PROGRAM TITLE	DEGREE(S)
KY	Morehead State University Morehead	Environmental Studies	B.S. A.B.
		Mining Technology	A.A.S.
	Pikeville College Pikeville	Mining Technology	A.M.T.
	University of Kentucky Lexington	Energy (Coal) Engineering	M.S. Ph.D.
		Environmental Engineering	M.S. Ph.D.
	University of Louisville Louisville	Environmental Engineering	B.S. M.Eng.
	Western Kentucky University Bowling Green	Environmental Science	B.S.
		Environmental Engineering	B.S.
LA	Delgado College New Orleans	Urban Pest Management	A.S.
		Water/Wastewater Technology	A.S.
		Environmental Health Technology	A.S.
	McNeese State University Lake Charles	Environmental Science	B.S. M.S.
ME	Eastern Maine Vocational Technical Institute Bangor	Environmental Control Technology	A.A.S.
	New England Regional Wastewater Institute (S. Maine Vocational Technical Institute) S. Portland	Wastewater Treatment Technology	Cert.

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STATE	INSTITUTION	PROGRAM TITLE	DEGREE(S)
	University of Maine-Orono Orono	Sanitary Engineering	M.S.C.E. Ph.D.
MD	Charles County Community College La Plata	Pollution Abatement Technology	A.A.
	Johns Hopkins University Baltimore	Environmental Engineering	M.A. M.S.E. M.S. Ph.D
	University of Maryland College Park	Environmental Engineering	M.S.
		Nuclear Engineering	M.S.
		Pest Management	M.S.
MA	Harvard University Cambridge	Environmental Health Sciences	S.M. Sc.D.
		Environmental Sciences and Engineering	S.M. M.E. Ph.D.
		Toxicology	S.M. Sc.D.
	Massachusetts Institute of Technology Cambridge	Acoustics	S.M. Sc.D./ Ph.D.
		Environmental Engineering	Env.E.
		Mineral Resources Engineering and Management	S.M. Engr. Sc.D./ Ph.D.

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STATE	INSTITUTION	PROGRAM TITLE	DEGREE(S)
	Massachusetts Institute of Technology (Cont'd)	Nuclear Engineering	S.B. S.M. N.E. Sc.D./ Ph.D.
		Water Resources and Environmental Engineering	S.B. S.M. Sc.D./ Ph.D.
		Wastewater Treatment Plant Operations	Cert.
	Northeastern University Boston	Environmental Engineering and Science	M.S.
	Springfield Technical Community College Springfield	Environmental Technician	A.S.
	Tufts University Medford	Environmental Health Engineering	B.S.C.E. M.S.
	University of Lowell Lowell	Radiological Health Physics/Radiological Sciences and Protection	B.S. M.S.
		Wastewater Treatment Plant Operations	Cert.
MI	Ferris State College Big Rapids	Environmental Health Technician	A.A.S.
		Environmental Health	B.S.
	Michigan State University East Lansing	Environmental Conservation Education	M.S. Ph.D.
		Environmental Engineering	B.S.C.E. M.S. (emphasis) Ph.D. (emphasis)

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STATE	INSTITUTION	PROGRAM TITLE	DEGREE(S)
	Michigan State University (Cont'd)	Natural Resources and Environmental Education	B.S.
		Systems Science (Ecological Systems)	B.S. M.S. Ph.D.
	Michigan Technological University Houghton	Environmental Engineering	B.S.C.E. B.S.E. M.S.C.E.
	University of Michigan Ann Arbor	Environmental Education	M.S.
		Environmental Sciences Engineering	B.S.
		Industrial Hygiene and Air Pollution	M.P.H. M.S. Dr.P.H. Ph.D.
		Radiological Health	M.P.H. M.S. Dr.P.H. Ph.D.
		Water Resources: Engineering	M.S.E. Ph.D.
		Management Science	M.S. Ph.D.
		Water Quality	M.P.H. M.S. Dr.P.H. Ph.D.
MN	Bemedji State College Bemedji	Environmental Studies	B.S. M.A.
	Macalester College St. Paul	Environmental Studies	B.A. B.S.
	University of Minnesota Minneapolis	Environmental Health	M.P.H. M.S. Ph.D.

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STATE	INSTITUTION	PROGRAM TITLE	DEGREE(S)
MS	Mississippi State University Mississippi State	Specialized Training in Pest Management	M.Ag.
MO	Missouri Southern State College Joplin	Environmental Health Technology	A.S. B.S.
		Radiologic Technology	A.S.
	St. Louis Community College at Forest Park St. Louis	Radiologic Technology	A.S.
	University of Missouri-Columbia Columbia	Sanitary Engineering	B.S. M.S. Ph.D.
	University of Missouri-Rolla Rolla	Environmental and Sanitary Engineering	M.S. Ph.D.
	Water and Wastewater Technical School Neosho	Water and Wastewater Training	Cert.
	Washington University St. Louis	Air (emphasis)	M.S. D.Sc.
MT	Montana State University Bozeman	Environmental Engineering	M.S.
		Environmental Health Technology	M.S.
	Northern Montana College Havre	Environmental Health Technology	A.A. Cert.
NE	Central Technical Community College Hastings	Agriculture Technology	Cert. 1-Year Diploma 2-Year Diploma A.A.S. A.S.

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STATE	INSTITUTION	PROGRAM TITLE	DEGREE(S)
	University of Nebraska Lincoln	Sanitary Engineering	B.S. M.S. Ph.D.
		Water Resources Engineering	M.S.
		Planning and Management	M.S.
NH	University of New Hampshire Durham	Entomology	B.S. B.A.
NJ	Middlesex County College Edison	Environmental Health Science Technology	A.A.S.
	New Jersey Institute of Technology Newark	Interdisciplinary Studies in Environmental Engineering	M.S.
	Princeton University Princeton	Energy Conversion and Resources	Topical Programs
	Rutgers-SUNJ New Brunswick	Biology (option in entomology)	B.S. B.A.
		Entomology and Economic Zoology	M.S. M.P. Ph.D.
		Environmental and Business Economics	B.S.
		Environmental Science	M.S. Ph.D.
		Environmental Studies	B.S.
		Environmental and Water Resources Engineering	M.S. Ph.D.
		International Environmental Studies	B.A. B.S.

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STATE	INSTITUTION	PROGRAM TITLE	DEGREE(S)
	Rutgers-SUNJ (Cont'd)	Radiation Sciences	M.S. Ph.D.
	Stevens Institute of Technology Hoboken	Air Pollution Control Engineering	Cert.
		Water and Wastewater Engineering	Cert.
NM	New Mexico State University Las Cruces	Pest Management	B.S.
	University of New Mexico Albuquerque	Nuclear Engineering	M.S. Ph.D.
NY	Clarkson College Potsdam	Civil and Environmental Engineering	B.S. M.S.
	Columbia University New York City	Nuclear Engineering	B.S. M.S. Nuc.Engr. Eng.Sc.D.
	Cornell University Ithaca	College Program in Energy Conversion	B.S.
		Environmental Engineering	B.S. M.S. M.Eng. Ph.D.
		Waste Management Engineering	M.S. M.Eng. M.P.S. Ph.D.
		Nuclear Engineering	M.Eng. M.S. Ph.D.
	Hofstra University Hempstead	Solid Waste Management	Cert.
	Hudson Valley Community College Troy	Public Health Technology (Environmental option)	A.A.S.

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STATE	INSTITUTION	PROGRAM TITLE	DEGREE(S)
	Hunter College New York City	Environmental Health Science	B.S. M.S.
	Manhattan College New York City	Environmental Engineering and Science	M.S. M.E.
	Polytechnic Institute of New York New York City	Energy Engineering and Policy	Cert. M.S.
		Environmental Engineering and Planning	M.S.C.E. M.E.H.S. Engr. Ph.D.
	Rensselaer Polytechnic Institute Troy	Environmental Engineering	B.S. M.E. M.S. D.E. Ph.D.
		Nuclear Engineering	B.S. M.S. M.E. Ph.D.
	Rochester Institute of Technology Rochester	Civil Engineering Technology (Environmental option)	B.T.
	State University of New York-Buffalo Buffalo	Water Resources and Environmental Engineering	B.S. M.S. Ph.D.
	State University of New York Farmingdale	Pest Control Technology	A.A.S.
	Syracuse University Syracuse	Chemical Engineering	B.S. M.S. Ph.D.
		Environmental Engineering	B.S.
		Sanitary Engineering, Sanitary Science, Civil Engineering	M.S.(S.E.) M.S.(S.S.) Ph.D.

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STATE	INSTITUTION	PROGRAM TITLE	DEGREE(S)
	The Cooper Union New York City	Integrated Master's Program with concentration in Environmental Engineering	M.E.
	Ulster County Community College Stone Ridge	Water Quality Management Training	A.A.S.
	University of Rochester Rochester	Toxicology Training Program	M.S. Ph.D.
NC	Duke University Durham	Environmental Management	M.E.M.
		Civil Engineering/ Urban and Environmental Engineering	M.S. Ph.D.
	North Carolina State University Raleigh	Agricultural Pest Control	A.A.S.
		Pest Management	B.S. M.S. (minor)
		Air Conservation	M.S. (minor) M.E. (minor) Ph.D.(minor)
		Environmental Engineering	M.S. M.C.E. Ph.D.
		Acoustic, Noise Vibration	M.S. M.M.E. Ph.D.
	University of North Carolina Chapel Hill	Air and Industrial Hygiene	M.S. M.S.P.H.
		Environmental Chemistry and Biology	M.S. M.S.P.H. Ph.D.

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STATE	INSTITUTION	PROGRAM TITLE	DEGREE(S)
	University of North Carolina (Cont'd)	Environmental Management Protection	M.S. M.S.P.H. Ph.D.
		Radiological Hygiene	M.S. M.S.P.H. Ph.D.
		Water Resources Engineering	M.S. M.S.P.H. M.S.E.E. Ph.D.
	Wilson County Technical Institute Wilson	Sanitary Landfill Operating Manager	Cert. Diploma A.A.S.
		Sanitary Landfill Technology	A.A.S.
ND	North Dakota State School of Science Wahpeton	Environmental Science Technology	A.A.
OH	Antioch College Yellow Springs	Environmental Studies	B.S.
	Hocking Technical College Nelsonville	Environmental Health Technology	A.A.S.
	Miami University Oxford	Environmental Science	M.En.
	Muskingum Area Technical College Zanesville	Environmental Quality Control Technology	A.A.S.
		Natural Resources Conservation Technology	A.A.S.
		Petroleum Engineering Technology	1-Year Cert. A.A.S.
	Ohio State University Columbus	Agricultural Engineering	B.S. M.S. Ph.D.

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STATE	INSTITUTION	PROGRAM TITLE	DEGREE(S)
	Ohio State University (Cont'd)	Chemical Engineering (air)	B.S. M.S. Ph.D.
		Civil Engineering	B.S. M.S. Ph.D.
		Environmental Biology	M.S. Ph.D.
		Environmental Education	B.S.(Ed.) B.S.(N.R.) M.S. Ph.D.
		Toxicology (Pharmacology)	M.S. Ph.D.
	Ohio University Athens	Environmental Studies	M.S.
	Raymond Walters General and Technical College (University of Cincinnati) Cincinnati	Environmental Control/ Protection Technology	A.S.
	University of Cincinnati Cincinnati	Air Pollution and Industrial Hygiene	M.S. Ph.D.
		Civil and Environmental Engineering	M.S. Ph.D.
		Environmental Health	M.S. Ph.D.
		Mechanical and Industrial Engineering (noise)	B.S. M.S. Ph.D.
		Occupational Medicine	M.S. Ph.D.
		Toxicology	M.S. Ph.D.

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STATE	INSTITUTION	PROGRAM TITLE	DEGREE(S)
	University of Cincinnati (Cont'd)	Acoustics and Noise Control	B.S. M.S. Ph.D.
	University of Toledo Toledo	Chemical Engineering, Civil Engineering	B.S. M.S.
		Engineering Science	M.S.
OK	East Central Oklahoma State University Ada	Environmental Science	B.S.
	OSU Oklahoma City Technical Institute Oklahoma City	Civil Technology	A.S.
	Oklahoma State University Stillwater	Engineering Technology	A.D. B.S.
		Radiation and Nuclear Engineering Technology	A.D. B.S.
	Oscar Rose Junior College Midwest City	Wastewater Technology	A.A.S.
		Environmental Science	A.A.S.
	University of Oklahoma Norman	Environmental Science	B.S. M.S. Ph.D.
OR	Linn-Benton Community College Albany	Wastewater Technology	A.S.
		Water/Wastewater Technology	A.S.
		Water/Wastewater Plant Operator	Cert.
	Oregon Institute of Technology Klamath Falls	Environmental Technology	A.A.S. B.T.
	Oregon State University Corvallis	Nuclear Engineering Technology	B.S.
		Nuclear Engineering	B.S. M.S.

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STATE	INSTITUTION	PROGRAM TITLE	DEGREE(S)
	Oregon State University (Cont'd)	Pest Management and Plant Pathology	B.S. M.S.
	Portland State University Portland	Engineering and Applied Science	B.S. M.S.
PA	Carnegie-Mellon University Carnegie Institute of Technology Pittsburgh	Environmental Engineering	B.S. M.S. Ph.D.
	Drexel University Philadelphia	Environmental Engineering and Science	M.S.E.E. M.S.E.S. Ph.D.
	Pennsylvania State University University Park	Acoustics	M.E. M.S. Ph.D.
		Air Pollution Control Technology	A.A.P.C.T.
		Entomology	B.S. M.Agr. M.S. Ph.D.
		Environmental Engineering	B.S. M.S. M.E.E.E. Ph.D.
		Environmental Pollution Control	M.S. M.E.P.C. M.E.
		Environmental Resource Management	B.S.
		Minerals Processing	M.S. Ph.D.
		Mining Technology	A.A.S.

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PARTICIPATING INSTITUTIONS

STATE	INSTITUTION	PROGRAM TITLE	DEGREE(S)
	Pennsylvania State University (Cont'd)	Mining Engineering	B.S. M.S. M.E. Ph.D.
		Nuclear Engineering Technology	A.N.E.T.
		Nuclear Engineering	B.S. M.S. M.E. Ph.D.
		Petroleum and Natural Gas Engineering	B.S. M.S. Ph.D.
		Water Resources Engineering Technology	B.T.
	Slippery Rock State College Slippery Rock	Environmental Studies	B.S.
	Temple University Philadelphia	Environmental Technology	A.T.
		Environmental Engineering Technology	B.S.
	University of Pennsylvania Philadelphia	Energy Engineering	M.S.E.
		Energy Management and Policy	M.S.E.M.P. Ph.D.
	University of Pittsburgh Pittsburgh	Environmental and Sanitary Engineering	B.S. M.S. Ph.D.
		Environmental Systems Engineering	degrees granted through Engr. Dept.
	School of Public Health (University of Pittsburgh) Pittsburgh	Acoustic Environmental Control	M.S.(Hyg.) D.S.(Hyg.)
		Air Resources	M.S.(Hyg.)

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STATE	INSTITUTION	PROGRAM TITLE	DEGREE(S)
	School of Public Health (University of Pittsburgh) (Cont'd)	Environmental Health Engineering	M.P.H. D.S.(Hyg.)
		Environmental Health Planning	D.S.(Hyg.)
		Health Aspects of Water Quality	M.S.(Hyg.)
		Industrial Hygiene	M.S.(Hyg.)
		Toxicology	D.S.(Hyg.) Ph.D.
		Radiation Health	M.S.(Hyg.) D.S.(Hyg.) Ph.D. D.P.H.
RI	University of Rhode Island Kingston	Environmental Engineering	B.S. M.S. Ph.D.
SC	Clemson University Clemson	Air Pollution	M.S. M.Engr.
		Natural Systems	M.S. M.Engr.
		Planning and Management	M.S. M.Engr.
		Water Treatment Systems	M.S. M.Engr.
		Environmental Systems Engineering	Ph.D.
	Greenville Technical College Greenville	Wastewater Technology	A.A.S.
	Sumter Area Technical College Sumter	Environmental Engineering Technology	A.E.T.
TN	Chattanooga State Technical Community College Chattanooga	Environmental Science Technology	A.S.
		Nuclear Technology	A.S.

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STATE	INSTITUTION	PROGRAM TITLE	DEGREE(S)
	East Tennessee State University Johnson City	Environmental Health	B.S.E.H. M.S.E.H.
	Memphis State University Memphis	Audiology	M.A. Ph.D.
	Middle Tennessee State University Murfreesboro	Environmental Science and Technology	B.S.
	State Technical Institute at Memphis Memphis	Environmental Engineering Technology	A.E.
	University of Tennessee Knoxville	Environmental Engineering	M.S.E.E. M.E. Ph.D.
		Environmental Engineering (Air Quality and Pollution Control)	M.S.E.E. M.E. Ph.D.
		Environmental Engineering (Water Pollution Control/ Water Resources)	M.S.E.E. M.E. Ph.D.
		Industrial Audiology	M.A.
		Nuclear Engineering	B.S. M.E. M.S. Ph.D.
		Water Resources Development	M.S.
	Vanderbilt University Nashville	Environmental and Water Resources Engineering (EWRE)	B.E.
		Environmental Science	B.S.
		EWRE (Environmental Science)	M.S. M.Eng. Ph.D.

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STATE	INSTITUTION	PROGRAM TITLE	DEGREE(S)
	Vanderbilt University (Cont'd)	EWRE (Air Resources)	M.S. M.Eng. Ph.D.
		EWRE (Solid Waste)	M.S. M.Eng. Ph.D.
		EWRE (Water and Wastewater Treatment/Water Resources)	M.S. M.Eng. Ph.D.
TX	Baylor University Waco	Institute of Environmental Studies	B.A. B.S.
	Lamar University Beaumont	Environmental Science	B.S.
		Energy Resource Management	B.S.
	Rice University Houston	Environmental Science and Engineering	M.S.
	Sam Houston State University Huntsville	Environmental Science	B.S.
	Texas A & M University College Station	Environmental Engineering	M.S. Ph.D.
		Entomology	M.S.
		Entomology/Pest Management Option	M. Ag.
	Texas State Technical Institution Waco	Nuclear Technology	A.A.S.
		Water/Wastewater Technology	A.A.S.
		Water Utility Operator	Certificate
	University of Texas Austin	Environmental Health Engineering	M.S. Ph.D.
		Water Resources Engineering	M.S. Ph.D.

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STATE	INSTITUTION	PROGRAM TITLE	DEGREE(S)
UT	Brigham Young University Provo	Chemical Engineering	B.S. M.S.
		Water Resources and Environmental Engineering	B.S. M.S.
	University of Utah Salt Lake City	Civil Engineering	B.S. M.E. M.S. Ph.D.
	Utah State University Logan	Civil and Environmental Engineering	B.S. M.S. Ph.D.
		Pest Management	B.S. M.S.
		Environmental Studies	B.S.
VA	George Washington University NASA-Langley Institute Hampton	Acoustics	M.S. Sc.D.
		Environmental Modeling	M.S.
	J.Sargeant Reynolds Community College Richmond	Environmental Technology Environmental Operations	Cert. A.A.S.
		Ground Water Resources	Cert.
	Virginia Polytechnic Institute and State University Blacksburg	Civil Engineering Technology	B.S.
		Sanitary Engineering/Environmental Sciences and Engineering/Civil Engineering	M.S. Ph.D.
	Wytheville Community College Wytheville	Environmental Technology	Cert.

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STATE	INSTITUTION	PROGRAM TITLE	DEGREE(S)
WA	The Evergreen State College Olympia	Coordinated Studies	B.A.
	University of Washington Seattle	Environmental Studies	B.A. B.S.
		Air Resources	M.S. Ph.D.
	Washington State University Pullman	Environmental Science	B.S. M.S.
		Chemical Engineering	M.S.
		Air Pollution Control Engineering	M.S.
		Air Pollution Science	M.S.
		Air Pollution Option	M.S.
		Air Pollution Program	M.S.
	Western Washington University Bellingham	Environmental Studies	B.S.
WV	Bluefield State College Bluefield	Mining Engineering Technology	A.S. B.S.
	West Virginia Institute of Technology Montgomery	Mining Engineering Technology	A.S.E.M.T. B.E.M.T.
	West Virginia University Morgantown	Engineering of Mines	B.S.
		Environmental Engineering	M.S.C.E. M.S.E.
		Mineral Processing Engineering	B.S. M.S.
		Mineral Resource Economics	M.S.
		Petroleum Engineering	B.S. M.S.

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STATE	INSTITUTION	PROGRAM TITLE	DEGREE(S)
WI	Marquette University Milwaukee	Environmental Engineering	B.A. B.S.
	Northland College Ashland	Environmental Studies	B.A.
	University of Wisconsin-Green Bay Green Bay	Environmental Emphasis	B.A. B.S. M.E.A.S.
	University of Wisconsin-Madison Madison	Civil and Environmental Engineering	B.S.
		Environmental Communications	M.A. M.S.
		Water Resources Management, Environmental Monitoring, Land Resources	M.S. Ph.D.
	University of Wisconsin-Milwaukee	Atmospheric and Marine Environmental Program	M.S. M.E.
WY	Casper College Casper	Water Quality Technology	A.S.
	University of Wyoming Laramie	Civil Engineering	M.S. Ph.D.

Other Programs

The following programs were included in the on-site visit process and offer training through various institutes, centers, state agencies, or college consortiums. Program descriptions can be found in the volume specified.

State	Institution	Program	Volume
FL	Florida Department of Environmental Regulation	Environmental Noise Control Training	Noise
	Miami-Dade Community College	NPDES Effluent Monitoring Training	Wastewater I
		Wastewater Treatment Plant Operations	Wastewater I
		Water Treatment Plant Operations	Potable Water I
	University of Miami School of Medicine	Pesticide Protection	Pesticides
KS	Kansas State University	Institute for Environmental Research	Composite II III Business and Industry
MI	Michigan State University	Institute of Water Research	Potable Water I
		Pesticide Research Center	Pesticides
NE	University of Mid-America	Pests, Pesticides and Pesticide Safety	Pesticides

State	Institution	Program	Volume
NJ	Princeton University	Environmental Science and Policy	Composite I
NC	U.S. Environmental Protection Agency	Air Pollution Training Institute	Air
OH	Ohio State University	Center for Lake Erie Area Research	Potable Water I
		Cooperative Extension Service Activities	Composite II and III
		Water Resources Center	Potable Water I
PA	Air Pollution Control Association	Refresher, Continuing Education Courses	Air
	University of Pittsburgh	Environmental Systems Engineering	Composite I
TN	Memphis State University	Nuclear Reactor Fundamentals	Energy
		Radiation Technician Training Course	Radiation
	Oak Ridge Associated Universities	Radiation Emergency Assistance Center/ Training Site	Radiation
		Special Training	Energy Radiation
	University of Tennessee Center For Health Sciences	Training Courses in Audiometric Orientation	Noise

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PROJECT FINDINGS

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I. A SUMMARY PROFILE OF REPRESENTATIVE RADIATION EDUCATIONAL PROGRAMS

A. States, Institutions, Programs and Degrees

The Post-secondary Education Profile looked at radiation training programs in fourteen states varying in size from technician training at the local level to advanced degree programs at the university. Included were programs offered for continuing education credits and certificates. This report contains information gathered from on-site interviews from various sources for a total of twenty-five radiation programs. Selection of these programs was based on a variety of factors including: information and recommendations obtained during the workforce assessment phase of this project; a review of the institution's program catalog; a review of other published sources of information regarding degree programs in environmental areas.

On-site visits and extensive interviews were conducted to assess each of these twenty-five programs. Many of the institutions visited had programs in several environmental areas (i.e., air and water, or potable water and wastewater).

As shown in Table 8, each program and its corresponding degree are listed. The total number of degrees by type shows that three of these programs offer continuing education units or certificates, eight offer an Associate degree, eight offer a Bachelors degree, fifteen offer various types of Masters degrees (e.g., Master of Engineering, Master of Science, Master of Science (Hygiene), Master of Public Health), and sixteen offer various forms of Doctorates (e.g., Ph.D., Sc.D., Doctor of Public Health, Doctor of Science - Hygiene).

B. Enrollment Statistics and Graduates

The average enrollment of the twenty-five institutions surveyed was 67. Some schools had as few as twelve students enrolled whereas a few had as many as 194 students enrolled in radiation programs at all levels.

At the associate degree level, of eight programs supplying enrollment data, the average enrollment was 41 students. Ninety-one percent (299) of the students enrolled at the Associate degree level were full-time and 31 (8%) were enrolled on a part-time basis.

The average enrollment at the Bachelors degree level was 77 students. The total enrollment of nine programs furnishing information was 689. Ninety-nine percent (680) were enrolled on a full-time basis.

Several Masters degree candidates were enrolled on a part-time basis (20% or 101) and the average enrollment was 34 students in each Masters program. The average enrollment at the doctorate level was 12 students and 87 percent were enrolled on a full-time basis.

Of 1,677 students accounted for in totals supplied by 43 separate degree programs, the largest percentage (41%) were enrolled in Bachelors degree programs. Thirty percent were enrolled in Masters programs, 20 percent in Associate degree programs and only nine percent were enrolled in Doctoral programs.

Although the enrollment figures for radiation programs included in this study do not represent the actual total number of students enrolled in all radiation programs, of the programs represented in this volume, Standard Federal Region IV has the greatest enrollment (26%). Because of the availability of industrial employment in Region II in large metropolitan centers, Region II has the largest number of part-time students enrolled. Region I graduates the largest number of students in the seven federal regions that are included in this study.

Standard Federal Regions II and IV have the largest total enrollments in radiation programs. Possibly the greater movement of people south, particularly the elderly, and the already substantial and rising number of nuclear facilities, account for the large number of persons enrolled in Region IV programs. Region II contains large metropolitan centers and many of these programs are located in or near large cities which could provide employment in radiation protection. Regions III and IV show the largest increase in student enrollments, whereas very little change is detected in Regions I, II, VI and VII. Enrollment in Regions II and VII appear to be the most stable of the Standard Federal Regions.

The following table depicts the enrollment (full-time and part-time) in the radiation programs surveyed, as well as the average number of graduates per year and enrollment trends over the last three years.

TABLE 2

RADIATION ENROLLMENT PROFILE

Degree	Enrollment Full-time /	Part-time	Graduates Average # Per Year	Enrollment Change by Program Up /	Down /	Stable
Associate	299	44	131	2	3	3
Bachelor	680	9	148	3	0	5
Masters	401	101	181	9	0	8
Doctoral	119	24	55	3	1	7
TOTAL	1,499	178	515	17	4	23

On a national scale, the majority of the students (41%) are enrolled in Bachelors programs. However, almost as many (30%) are enrolled in Masters programs, and the fewest (9%) are enrolled in Doctoral programs.

Of the 44 degree programs supplying information on whether of not enrollment is increasing, declining or stabilizing, 23, or 52% indicated their enrollments have been stable. Almost as many respondents (39%) indicated that their enrollments have been increasing. Only 9% indicated that their enrollments have been declining over the last three years. The principal increase is at the Masters level (53%), and the principal decline is at the Associate degree level (75%). Of 17 Masters programs that responded to requests for enrollment change information, 47% (8) saw their enrollment stabilizing.

A greater percentage of Masters degree students (35%) complete their degree requirements than the second largest degree category (Bachelors - 29%). The greatest number of graduates (11%) receive doctorates.

C. Student Origin - In-State, Out-of-State, Foreign

In the twenty-five radiation programs that were contacted, it is apparent that mostly in-state students are enrolled in Associate and Bachelors degree programs. Including foreign students, at the Masters degree level, out-of-state students predominate in radiation program enrollments, as can be seen by the ratios in Table 8. Radiation programs with long-standing reputations, such as the programs at Rutgers and Rensselaer, for example, tend to attract a greater number of out-of-state and foreign students for advanced degrees. At Pennsylvania State University, about 50% of the enrollment in the nuclear engineering graduate program is comprised of foreign students. Graduate students are attracted by the financial aid and the research facilities offered by graduate programs in this field.

D. Employment

At the Associate degree level, most graduates of the programs surveyed find jobs with either industrial firms or with governmental agencies, and serve as technicians. Relatively few have joined consulting firms. Those who have are assisting in the preparation of environmental impact statements for reactor sites and perform monitoring tasks. Nuclear technicians assist professional engineers in radiation safety, reactor operations, radionuclide handling, nuclear and control instrumentation, fuel fabrication and health physics. Education officials surveyed indicated that employment for Associate degree graduates has become increasingly difficult to obtain in comparison with the high demand of a few years ago.

Bachelors degree graduates are usually qualified to hold positions in research, development, design, manufacture, and operations of nuclear systems. Most (two-thirds) tend to obtain private sector positions in industry, utilities, or architectural engineering firms.

At the advanced degree level, many graduates tend to obtain positions with either governmental or medical institutions. A much wider variety of positions is available to advanced degree graduates than at either the Associate or Bachelors degree levels. The Health Physics Society's Placement Services is often an excellent source for assistance in securing employment in this field.

The following table depicts, by degree level, the employment status of graduates of the programs surveyed in radiation.

TABLE 3

RADIATION EMPLOYMENT SUMMARY

Degree	Private Sector Industry	 Consulting	Total	Gov't	Other
Associate	27%	6%	33%	65%	2%
Bachelor	42%	11%	53%	28%	19%
Masters	28%	10%	39%	30%	31%
Doctoral	17%	10%	27%	31%	42%

The data in Table 3 were compiled by utilizing the average annual graduates figures within each program and obtaining employment figures in real numbers. These real numbers for each program were then totaled and reworked into total percentages. Similarly, the national averages were computed using real numbers.

At the Associate degree level, Regions IV and VII have a predominant employment of radiation technicians in government. Regions I and VI have greater percentages of graduates at this level employed in industry. Nationally it is apparent from referring to the above table that Associate degree students find about twice as many jobs in government than in industry.

Students find more jobs in the private sector than government at the Bachelors degree level (about 50% more). This is especially apparent from information received from Regions I, III, and VI.

At the advanced degree level (e.g., M.S., M.Eng., M.S.-Hyg., M.P.H., Ph.D., etc.) it appears that about 30 percent each find private, government, and other jobs. The other 11 categories may include jobs within hospitals, academia, or research laboratories. Region II appears to have employed more advanced degree graduates in government, whereas Region III programs have a significantly larger percentage employed in industry.

F. Faculty

In Table 8 on page 63, the reader will notice that of the 207 faculty members associated with these 27 radiation programs (including certificate and continuing education), approximately 72% or 160 are full-time and 28% or 63 are part-time. Some faculty members are actually students conducting research or instructing students. Although a student-faculty ratio can be developed, it would be less than meaningful because some faculty members are engaged primarily in research. In addition, a variety of departments supply faculty for occasional courses in for example, an interdisciplinary environmental studies undergraduate major. Furthermore, some faculty members teach courses other than those offered as part of their environmental program.

F. Internship/Applied Study Terms

In the radiation area, 14 of the 27 (52%) programs offer work study. Applied study terms are a very active and integral (though not required) part of many of the radiation training programs. Basically, two plans exist: alternating co-ops - a semester in residence and a semester on the work location; and parallel co-ops - work one-half time and attend class one-half time. At Rutgers, Radiation Science program students may obtain summer internships available at the Brookhaven National Laboratory at Long Island, New York. Because of the unavailability of financial assistance at Rutgers, many students support themselves by working as nuclear medical technicians, health physicists, radiation safety officers, and research assistants at nearby hospitals and laboratories.

G. Graduate Follow-up

One of the key factors in postsecondary education profile was the determination of graduate placement from the programs visited. Twenty (74%) of twenty-seven programs contacted had some method of following up on where their students were employed. Newsletters, mail surveys and alumni meetings were the means most often employed to keep current graduate lists.

II. ADDITIONAL FINDINGS

A. Recruitment Techniques

The various colleges and university programs surveyed employ a wide variety of recruiting techniques to attract students to their programs. Requests for recruitment information were received from twenty-two radiation programs and a total of thirty-seven recruitment techniques were used to advertise the existence of the programs to prospective applicants.

Nine programs (41%) do not consider it necessary to recruit because of an abundance of applicants. The reputation of the program was most often cited as the main reason why the programs attracted many applicants.

Six programs (27%) send recruitment information packets to each inquiring student or mail brochures to undergraduate programs or high schools.

Five programs (23%) rely upon high school visitations and those doing so are usually community colleges or state technical colleges. Some programs visit high school counselors and others had faculty members speak to high school clubs. One program's faculty attended a high school vocational-day and answered student's inquiries.

Introductory and short courses attracted applicants to three programs (14%) whereas three others relied principally upon admission office efforts. Two respondents (9%) did not consider their present recruitment techniques to be very adequate. Numerous other techniques were used for recruitment and include on-campus advertising; personal replies to individual student inquiries; advertisement in professional magazines and newspapers; exhibits at shopping malls and career day fairs; and postings on bulletin boards. Rutgers' Radiation Science program found a very effective recruitment technique in writing to the undergraduate programs of its graduate students to inquire as to which courses offered were considered most helpful for graduate school preparation. This also served to demonstrate Rutger's concern for its student's needs and prompted them to apply to the Rutgers program.

B. Research Funding and Sources of Student Support

The radiation programs receive a diversity of funding and the most common sources are the Department of Energy, the Nuclear Regulatory Comission, the National Science Foundation, and the Electric Power Research Institute. Associate degree programs usually have no research funding but do receive support for equipment and facilities from a variety of sources. Funding sources of some of these programs are from medical centers and industrial contracts.

Twenty-nine different funding sources were described by twenty radiation programs and the Energy Research and Development Administration was most often cited as the major funding source of eight (40%) programs. The Electric Power Research Institute and the Nuclear Regulatory Commission provided funding of four (20%) of the program's surveyed. Three programs (15%) received funding from the National Science Foundation for research.

Beyond the above cited funding sources, a wide variety of other institutions provide research funding. These include among others: the U.S. Bureau of Radiological Health; the National Institutes of Health; power companies; research institutes; national laboratories; and foundations. Oklahoma State University received a research grant from Algeria to conduct contract research. Private corporations such as the Florida Phosphate Corporation have also sponsored research to be conducted by universities.

Students receive support from federal grant programs, graduate teaching and research assistantships, training grants, jobs, and many other sources to assist them in defraying their educational expenses. Information was obtained from twenty-three programs on nineteen different types of funding sources. Graduate teaching and research assistantships were most often cited as the major financial assistance source by nine programs (39%). These assistantships may be derived from university, military or other funding sources.

Summer internship and cooperative applied study programs (mostly undergraduate) are also a major source of financial assistance to students. Internships have been obtained at the U.S. Bureau of Radiological Health, U.S. Environmental Protection Agency laboratories and the National Institute of Environmental Health Sciences. Internship and co-op programs are utilized by seven institutions (30%).

U.S. Department of Energy (DOE) and military and industrial fellowships provide financial assistance to four program's (17%) students whereas traineeships from DOE and the National Institute of Occupational Safety and Health assist the students of five (22%) other programs. Most students participating receive financial assistance from the federally run work-study, grant and loan programs such as the Basic Educational Opportunity Grant Program. Other students receive support from a wide variety of sources including state tuition grants and loans, university scholarships, part-time and full-time jobs, state and industrial funded graduate research contracts, graduate fellowships, employer paid tuition and foreign governments.

C. Usage of ERIC and IRIS

ERIC and IRIS are federally maintained computer retrieval systems encompassing educational resource materials on a national scale. IRIS is an EPA generated compilation of information pertaining to water and wastewater. Since the effectiveness of any such system can best be measured by its application and use, Phase II was appropriately expanded to include an adjunct assessment of the "utilization profile" of the educational community.

It should be pointed out that the respondents to the assessment question, "have you ever used ERIC or IRIS?", were faculty rather than students, and that the findings contained in Table 4 should be interpreted accordingly.

TABLE 4

ERIC/IRIS UTILIZATION PROFILE - RADIATION

	Yes	No	Total Responding
ERIC	3	20	23
IRIS	2	21	23

Of all the environmental areas surveyed in Phase II (air, noise, pesticides, potable water, radiation, solid waste, wastewater and energy), Table 5 depicts the total number of responses.

TABLE 5

ERIC/IRIS UTILIZATION PROFILE - PHASE II SUMMARY

	Yes	No	Total Responding
ERIC	72	307	377
IRIS	64	314	378

D. Program Flexibility

TABLE 6

TIME REQUIRED TO IMPLEMENT A COMPLETE CONTENT CHANGE IN A COURSE

Degree Program	Less than 1 month	1 month-1 year	more than 1 year; less than 2	2-4 years	more than 4 years	Undetermined
Associate	2	3	0	0	0	3
Bachelors	2	4	1	0	0	1
Masters	3	6	2	0	0	3
Doctoral	3	4	1	0	0	2
TOTAL	10	17	4	0	0	9

Twenty-four separate radiation training institutions were contacted for program flexibility information. Including all four basic degree levels between the associate to doctorate, a total of 40 separate degrees were included in the survey. Responses were obtained from fifteen (63%) of the twenty-four institutions contacted. Eight Associate, nine Bachelors, fourteen Masters and ten Ph.D. degree programs were contacted for curriculum flexibility information.

Of forty degree programs, seventeen (43%) said that it took between one month to one year to implement course content changes. Ten (25%) of the programs took less than one month to change courses and 4 (10%) took between one to two years. Nine programs (23%) could not provide any information.

TABLE 7

TIME REQUIRED TO IMPLEMENT A COMPLETE CONTENT CHANGE IN A PROGRAM

Degree Program	Less than 1 month	1 month-1 year	more than 1 year; less than 2	2-4 years	more than 4 years	Undetermined
Associate	3	1	2	0	0	2
Bachelors	1	4	2	0	0	1
Masters	1	3	2	0	0	8
Doctoral	1	5	2	0	0	2
TOTAL	6	13	8	0	0	13

Seventeen (43%) of the forty degree programs contacted took between one to two years to implement content changes in a program Eleven (28%) took one month to a year, four (10%) took less than one month, and two (5%) took three to five years to make any such changes. Ten separate degree programs (25%) could not supply the requested information.

E. Environmental Occupations

Of the eight programs offering Associate degrees, five (63%) provided occupational information on which careers they considered their graduates to be qualified to hold. Three of the five (60%) programs feel that they are training their students for the following occupations:

Health Physics Monitor
Health Physics Technican
Radiologist Technican

Two (40%) programs train their graduates for positions as Nuclear Materials Technicians and Radiological Safety Technicians. Other occupations listed by associate degree programs include the following:

Radiation Protection Trainee
Radiation Therapy Technologist
Veterinary Radiologist
Radiation Inspector
Radiological Health Specialist
Nuclear Quality Assurance Inspector
Nuclear Quality Control Technician

Occupational information was received from only two (40%) Bachelors programs of five contacted. Both programs train their students to hold the following positions, among others:

Health Physics Monitor
Health Physics Technician
Nuclear Instrumentation/ Control Technician
Radiation Inspector
Radiation Physicist
Radiological Health Specialist

At the Masters level (including M.P.H.), three of four (75%) programs provided occupational information. The following occupational titles were most commonly listed by these programs:

Biophysicist (Radiation)
Health Physics Monitor
Medical Radiation Physicist
Radiation Engineer
Radiation Physicist
Radiological Health Specialist

Two programs offering doctorates, of a total of three Universities contacted at this level, supplied occupational information. Both programs stated that their graduates were qualified as Medical Radiation Physicists, Radiation Physicists, and Radiological Health Specialists.

Other occupational titles listed include:

Environmental Radiologist
Radiation Engineer
Radiochemist
Environmental Engineer
Industrial Engineer
Industrial Hygienist
Meteorologist
Biophysicist

These occupational titles can be assumed to be valid only for those institutions supplying this information.

III

A Summary Profile of Representative Educational Programs

The following footnotes (1-6) refer to the various column headings of the Table. Other footnotes are specific to the figures which were provided by various institutions and are used throughout the Table.

[1] Enrollment - 1976-77 statistics

[2] Graduates - average for last three years; 'change' indicated apparent trends within that three year period

[3] Employment - 'other' includes positions such as those found within the educational community

[4] Faculty - full-time and part-time is determined by individual institutions

[5] Internship/Applied Study - part of an option to obtain a degree; may or may not have financial reimbursement connected with it.

[6] Graduate Follow-up - a standardized procedure that enables the institution to periodically determine the employment of their graduates

[7] Refers to Industry and Consulting collectively

[8] Health-related occupations

[9] Refers to enrollment trend

[10] Estimated

[11] There are also several adjunct faculty members from the medical college that teach in the program

[12] Juniors and Senior only

[13] Academic

[14] Abberrations due to drastic enrollment fluctuation

[15] Faculty members also include several hospital physicians who assist in training students

[NA] Not Applicable/Not Available

[*] Asterisk denotes that a program appears in more than one volume of the profile.

TABLE

A SUMMARY PROFILE OF REPRESENTATIVE

STATE	INSTITUTION	PROGRAM	DEGREE	ENROLLMENT[1]		GRADUATES[2]	
				FULL TIME	PART TIME	No. / YEAR	CHANGE
CT	Hartford State Technological College	*Nuclear Engineering Technology	A.S.	12	0	10	Down
FL	Central Florida Community College	Radiological Health Technology	A.S.	112	44	45	Up
	University of Florida	Radiological Sciences	M.E. M.S.				Stable
GA	Southern Technical Institute	*Nuclear Safety	A.S.	10	0	0	Down[9]
KS	Kansas State University	*Nuclear Engineering	B.S.	100	0	17	Stable
			M.S.	13	2	5	Stable
			Ph.D.	9	1	3-4	Stable
	University of Kansas	Radiation Biophysics	B.A. B.S.	16	N/A	2-3	Stable
			M.S.	10	2	4	Stable
			Ph.D.	10	2	2-3	Stable
MD	University of Maryland	Nuclear Engineering	M.S.	25	0	5-8	Up
MA	Harvard University	*Environmental Health Sciences	S.M.			13	Stable
			Sc.D.			2	Stable
	Massachusetts Institute of Technology	*Nuclear Engineering	S.B.	30	0	N/A	N/A
			S.M		0	39	Up
			N.E.	150	0	7	Up
			Sc.D. Ph.D.		0	24	Up

8

RADIATION EDUCATIONAL PROGRAMS

STUDENT ORIGIN IN-STATE/ OUT-OF-STATE/ FOREIGN (%)	EMPLOYMENT				FACULTY[4]		INTERNSHIP/[5] APPLIED STUDY		GRADUATE[6] FOLLOW-UP	
	PRIVATE SECTOR		GOV'T	OTHER[3]	FULL TIME	PART TIME	YES	NO	YES	NO
	INDUSTRY	CONSULTING								
100/NA/NA	70%		30%		1	0	X		X	
70/25/5	89%[7]		10%	1%	3	0	X		X	
60/40/NA[10]				100%[8]	7	0	X		X	
80/20/NA	100%[10]				1	0		X	X	
70/30/NA	22%	22%	10%	45%[8]	8	2	X		X	
70/30/NA	22%	45%	10%	22%[8]				X	X	
70/30/NA	23%	23%	10%	43%[8]				X	X	
33/66/0	45%	5%	50%		4	1[11]		X	X	
20/62/8	45%	5%	50%					X	X	
20/62/8	45%	5%	50%	10%				X	X	
90/5/5	37%		37%	25%[13]	5	1		X	X	
40/60/NA	45%	25%	25%	5%	7	2	X		X	
40/60/NA	45%	25%	25%	5%			X		X	
NA/NA/33		N/A			25	0	X			X
NA/NA/33	15%	5%	30%	50%			X			X
NA/NA/33	64%		18%	18%			X			X
NA/NA/33	3%	6%	36%	55%			X			X

TABLE

A SUMMARY PROFILE OF REPRESENTATIVE

STATE	INSTITUTION	PROGRAM	DEGREE	ENROLLMENT[1]		GRADUATES[2]	
				FULL TIME	PART TIME	No. / YEAR	CHANGE
	University of Lowell	Radiological Science	B.S.	45	0	13	Stable
			M.S.	6	6	2	Stable
MI	University of Michigan	*Radiological Health[14]	M.P.H.	0	0	3	Stable
			M.S.	3	1	6-7	Up
			D.P.H.	0	0	0	Stable
			Ph.D.	2	5	1-2	Stable
MO	Missouri Southern State College	Radiologic Technology	A.S.	14	0	7	Stable
	St. Louis Community College at Forest Park	Radiologic Technology	A.S.	72	0	30	Stable
NJ	Rutgers-State University of New Jersey	Radiation Science	M.S.	8	37	12	Up
			Ph.D.			3	Stable
NY	Columbia University	*Nuclear Engineering	B.S.	35	0	15	Stable
			M.S.	20	15	15	Stable
			N.E.			1-2	Stable
			E.Sc.D.			2-3	Stable
	Cornell University	*Nuclear Engineering	M.E.	6	1	6	Stable
			M.S.	1	0	1	Stable
			Ph.D.	5	0	1	Down
	Rensselaer Polytechnic Institute	*Nuclear Engineering	B.S.	115	0	30	
			M.S. M.E.	50	12	18	
			Ph.D.	17	0	5	

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RADIATION EDUCATIONAL PROGRAMS

STUDENT ORIGIN IN-STATE/ OUT-OF-STATE/ FOREIGN (%)	EMPLOYMENT				FACULTY[4]		INTERNSHIP/[5] APPLIED STUDY		GRADUATE[6] FOLLOW-UP	
	PRIVATE SECTOR									
	INDUSTRY	CONSULTING	GOV'T	OTHER[3]	FULL TIME	PART TIME	YES	NO	YES	NO
90/10/NA	65%		25%	10%	3	2	X		X	
90/10/NA	65%		25%	10%				X	X	
25/75/0			100%		4	0	X		X	
25/75/0	50%	25%	10%	15%			X		X	
25/75/0	50%		50%					X	X	
25/75/0	50%	25%	10%	15%				X	X	
75/25/0	95%		5%		9[14]	0	X		X	
100/0/0	5%		20%	75%	4	0	X		X	
50/50/0	20%	10%	60%	10%	10	0	X		X	
50/50/0	20%	10%	60%	10%			X		X	
NA/NA/NA	75%		25%		7	0		X		X
NA/NA/NA	30%		60%	10%				X		X
NA/NA/NA								X		X
NA/NA/NA								X		X
NA/NA/NA					3	5		X		X
NA/NA/NA								X		X
NA/NA/NA								X		X
NA/NA/NA	30%	10%	40%	20%	11	6		X	X	
NA/NA/NA	30%	10%	40%	20%				X	X	
NA/NA/NA	30%	10%	40%	20%				X	X	

TABLE

A SUMMARY PROFILE OF REPRESENTATIVE

STATE	INSTITUTION	PROGRAM	DEGREE	ENROLLMENT[1] FULL TIME	PART TIME	GRADUATES[2] No. / YEAR	CHANGE
NC	University of North Carolina at Chapel Hill	Radiological Hygiene	M.S.				Stable
			M.S.P.H.			2	Stable
			Ph.D.	2	N/A	1	Stable
OK	Oklahoma State University	Engineering Technology	A.D.	13	0	9	Stable
			B.S.	38	0	9	Stable
PA	The Pennsylvania State University	*Nuclear Engineering Technology	A.A.S.	30	0	20	Down
		*Nuclear Engineering	B.S.	180	0	40	Up
			M.S.	28	4	14	Up
			M.E.	2	0	0	Up
			Ph.D.	9	1	2	
	University of Pittsburgh	Radiation Health	M.S.	13	18	9	Up
			D.SC.			1	
			Ph.D.				
			D.P.H.				
TN	Chattanooga State Technical College	Nuclear Technology	A.S.	36	N/A	10	Up
	Memphis State University	Radiation Technician Training Course	C.E.U.			N/A	Stable
			Cert.				
	Oak Ridge Associated Universities	Radiation Emergency Assistance Center/Training Site	Cert.			N/A	N/A
		Special Training	Cert			N/A	N/A

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RADIATION EDUCATIONAL PROGRAMS

STUDENT ORIGIN IN-STATE/ OUT-OF-STATE/ FOREIGN (%)	EMPLOYMENT				FACULTY[4]		INTERNSHIP/[5] APPLIED STUDY		GRADUATE[6] FOLLOW-UP	
	PRIVATE SECTOR INDUSTRY	PRIVATE SECTOR CONSULTING	GOV'T	OTHER[3]	FULL TIME	PART TIME	YES	NO	YES	NO
33/59/8	75%		25%		2	0		X	X	
33/59/8	75%		25%					X	X	
33/59/8	75%		25%					X	X	
70/30/NA	70%		30%		3	0		X	X	
69/30/1	70%		30%					X	X	
90/10/NA	44%	23%	33%					X	X	
80/20/NA	44%	23%	33%		16	0	X		X	
20/30/50	44%	23%	33%					X	X	
20/30/50	44%	23%	33%					X	X	
20/30/50	44%	23%	33%					X	X	
NA/NA/NA	40%	10%	40%	10%	[8]11	8	X		X	
NA/NA/NA	40%	10%	40%	10%				X	X	
NA/NA/NA	40%	10%	40%	10%				X	X	
NA/NA/NA	40%	10%	40%	10%				X	X	
100/0/0	25%		75%		2	0		X	X	
NA/NA/NA	N/A		N/A		0	6	N/A		N/A	
NA/NA/NA	N/A		N/A		4	15	N/A		N/A	
NA/NA/NA	N/A		N/A		4	15	N/A		N/A	

TABLE

A SUMMARY PROFILE OF REPRESENTATIVE

				ENROLLMENT[1]		GRADUATES[2]	
STATE	INSTITUTION	PROGRAM	DEGREE	FULL TIME	PART TIME	No. / YEAR	CHANGE
	University of Tennessee	*Nuclear Engineering	B.S.	121	9	21	Up
			M.E.	50	0	8	Up
			M.S.		0		Up
			Ph.D.		0	5	Up

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RADIATION EDUCATIONAL PROGRAMS

STUDENT ORIGIN IN-STATE/ OUT-OF-STATE/ FOREIGN (%)	EMPLOYMENT PRIVATE SECTOR INDUSTRY	EMPLOYMENT PRIVATE SECTOR CONSULTING	EMPLOYMENT GOV'T	EMPLOYMENT OTHER[3]	FACULTY[4] FULL TIME	FACULTY[4] PART TIME	INTERNSHIP/[5] APPLIED STUDY YES	INTERNSHIP/[5] APPLIED STUDY NO	GRADUATE[6] FOLLOW-UP YES	GRADUATE[6] FOLLOW-UP NO
67/28/5	30%		15%	60%	9	0	X			X
33/55/12			85%	9%			X		X	
30/55/15	15%						X		X	
30/55/5	32%		68%				X		X	

Photo reprinted from the
Michigan Technological
University Catalog 1975-76

PROJECT COMMENTARY

Photo reprinted from the
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Columbia Bulletin 1977

PROJECT CONSTRAINTS

In preparation for the on-site interviews, all of the institutions' catalogs were intensively reviewed in order to determine where environmental programs were being offered. During the course of this study, 171 institutions were visited and a total of 338 environmental programs, representing 45 states and Washington, D.C., were surveyed in detail. Albeit significant, these programs represent only a portion of all such programs available and cannot be construed as an in-depth survey of all environmental programs. It is, however, a representative sample within each of the environmental pollution control areas of Air, Noise, Pesticides, Radiation, Water and Wastewater, Solid Waste and Energy.

Several constraining factors to the proposed comprehensiveness of the study were encountered while collecting data from the institutions. It was disappointing to find that definitive records or statistics were generally unavailable which would describe specifically the placement of environmental program graduates. General indications of placement within categories, such as government or industry, were often available in percentages only. Depending on the size of the program and its age, some contact people could describe all graduates, others knew only where the past year's graduates were presently employed, and still others were aware only of their advisees entry-level positions and subsequent moves.

It also became clear during the on-site interviews that some programs of similar or identical content had different titles. This lack of clarity within the environmental areas serves to confuse the casual reader. For that reason, attention must be directed to the actual environmental course listings included in each program summary.

A list of terms commonly used during the on-site interviews and subsequently in this report was developed in order to facilitate precise data gathering. The reader is directed to Appendix II, TERMINOLOGY.

No attempt was made, in this report, to qualitatively judge any of these programs. The apparent absence of substantial qualitative measures in the environmental education field in general and the desire to collect data in a neutral atmosphere underscore the reasons for this omission. It appears that there is a need for the development of an environmental program model in each of these areas in order that some qualitative standards be provided where none now exist.

PROJECT COMMENTARY

Academic training programs in 14 states were examined in radiation areas in The Postsecondary Education Profile. Included were certificate through advanced degree levels, programs in areas such as nuclear engineering technology, radiological health technology, radiological sciences, nuclear safety, nuclear engineering, radiation biophysics, etc.

Of 1,677 total students enrolled in the 25 institutions included in the survey (43 separate degree programs), the largest percentage (41%) were enrolled in Bachelors degree programs. Thirty percent were enrolled in Masters programs, 20 percent in Associate degree programs and nine percent in Doctoral programs.

The average enrollment of the 25 academic institutions surveyed was 67 students. At the Associate degree level the average enrollment was 41; at the Bachelors level, 77; at the Masters level, 34; and 12 for the Doctoral level. More Masters degree candidates were enrolled on a part-time basis (20% or 101) than for any of the other degree programs.

Of the programs included in this volume, Region IV (26%) had the highest enrollment; whereas Region I graduated the largest number of students. Region II had the greatest number of part-time students enrolled.

Fifty-two percent of the 44 degree programs surveyed indicated that their enrollment was stable. Thirty-nine percent of the programs were experiencing increasing enrollments. The principal increase is at the Masters degree level whereas the main decline is within the Associate degree programs. Increasing numbers of foreign students are enrolling in advanced degree programs. For example, Penn State's nuclear engineering program reports a 50 percent foreign enrollment in its advanced degree programs.

Employment for Associate degree graduates appears to have become increasingly difficult to obtain in comparison with the situation of a few years ago. Two-thirds (67%) of bachelors degree graduates find private sector employment in industry, utilities or architectural engineering firms. Advanced degree graduates find it much easier to find either governmental or medical institute positions because of the greater diversity of jobs available at this level.

Associate and Bachelors degree graduates are finding about twice as many positions within the private sector as within the government. Advanced degree graduates are finding about 33 percent employment in each of three areas: industry, government, and in other areas (includes hospitals, academic and research laboratories).

Fourteen of the 27 (52%) separate degree programs offer internships. These applied study terms are usually alternating co-ops or parallel co-ops. Alternating co-ops are those which usually require a semester in residence and a semester at the work site. Parallel co-op students normally work half-time and attend classes half-time. Summer internships are also often available to many of the advanced degree program's students.

It was asked of those programs represented in this study what they anticipated for the future of environmental programs generally and of radiation training programs in particular. Seventeen (68%) of the twenty-five institutions contacted responded to this inquiry. Eight of the seventeen (47%) projected increased growth in the environmental area and several anticipated an increased shift to energy areas (including nuclear). Although most projected stabilized enrollments, increased demands were expected of graduates in radiological monitoring, nuclear waste management, and nuclear medicine.

LIST OF RADIATION TRAINING INSTITUTIONS

BY DEGREE

Photos reprinted from the Michigan
Technological University Catalog
1975-76

LIST OF RADIATION TRAINING INSTITUTIONS BY DEGREE

CERTIFICATE

Memphis State University
Oak Ridge Associated Universities

ASSOCIATES

Central Florida Community College
Chattanooga State Technical College
Hartford State Technical College
Missouri Southern State College
St. Louis Community College at Forest Park
Southern Technical Institute

BACHELORS

N/A

MASTERS

University of Florida
University of Maryland

MULTIPLE DEGREES OFFERED BY ONE INSTITUTION

Associate/Bachelors:
Oklahoma State University

Associate/Bachelors/Masters/Doctoral
Pennsylvania State University

Bachelors/Masters:
University of Lowell

Bachelors/Masters/Doctoral
Columbia University
Kansas State University
Massachusetts Institute of Technology
Rensselaer Polytechnic Institute
University of Kansas
University of Tennessee

Masters/Doctoral
Cornell University
Harvard University
Rutgers-State University of New Jersey
University of Michigan
University of North Carolina at Chapel Hill
University of Pittsburgh

RADIATION

TRAINING SUMMARIES

Photo reprinted from the 1976-77 Annual Report, Engineering Experiment Station, College of Engineering, University of Wisconsin, Madison

RADIATION TRAINING SUMMARIES

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Central Florida Community College . . . 89
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INSTITUTION: CENTRAL FLORIDA COMMUNITY COLLEGE (CFCC)

PROGRAM: Radiological Health Technology

DEPARTMENT: Radiological Health

DEGREE: Associate of Science

CONTACT: Mr. Frank Holland
Department of Radiological Health
Central Florida Community College
P.O. Box 1388
Ocala, Florida 32670
(904 237-2111

PROGRAM DESCRIPTION:

PROGRAM STRUCTURE

This two-year Radiation Health Technology program was begun in 1965, along with the Reactor Operator Technology program. Since its inception, it has grown in enrollment from eight students to one hundred and fifty-six, and the Reactor Operator Technology option is no longer offered.

Sources in the field indicate that graduates of this curriculum are being hired in preference to graduates of four-year programs. Radiation health related occupations which these graduates are qualified for are radiation health technologists and technicians, health physicists, and radiation control specialists.

Available to the student is an extensive laboratory facility and an inventory of sophisticated nuclear instrumentation. The University of Florida at Gainesville provides CFCC with both advisory support and the use of its reactor and related instrumentation through the Department of Nuclear Engineering Sciences.

Curriculum materials have been developed at CFCC to be used with courses which were felt to have inadequate or outdated coverage in conventional texts. Each course introduction is supplemented with a detailed course outline.

PROGRAM REQUIREMENTS

For entrance into this program, prospective students should complete high school or college algebra, chemistry and physics. Students should have a diploma from an accredited high school, or a Graduate Equivalency Diploma and satisfactory performance on the Florida Twelfth Grade Test, ACT test, or comparable standardized test. Licensing and security requirements are such that persons who have been convicted of a felony, or are color blind, or have epilepsy will probably not be able to find employment in radiation-related fields.

Two plans of study were available in the past; one leading to the Associate of Science degree, the other to a diploma showing technical competence. The latter is being discontinued in the near future for the reason that it is disadvantageous to the student in seeking employment.

The Associate of Science degree requires completion of sixty-seven credits, twenty-nine of which are Radiation Health Technology courses. An additional seventeen semester credits are of a related nature. Three hours of field work at the University of Florida or at a radiation-related industry are required. The remaining eighteen credits are designed to round out the students' skills in the social sciences and basic mathematics.

During the academic year 1976-1977, forty-seven students participated in the CFCC Coop Plan. This practice is encouraged because of the hands-on learning which takes place, and too because of the professional associations which develop. The coop may take one of two forms; the first being the Alternation Coop which has the student in full-time residence during one quarter and then employed in the field full-time the next; the Parallel Coop requires the student to work in the field part-time while he/she attends school part-time as well. Students receive pay on both plans.

CURRENT FACULTY, STUDENTS, GRADUATES

Three full-time faculty comprise the Radiological Health Technology Department. Nine additional departments have courses which are part of the required curriculum.

Three-fourths of the one hundred and twelve full-time and forty-four part-time students are Florida residents. While a large number of students are recent high school graduates, nearly forty percent are retraining for a new career. The number graduating has risen from the average of thirteen in 1976 to an anticipated forty-five in June of 1978.

Officials report that there are usually five positions open for each graduate to choose from, and nearly as many for coop placements. The campus placement office and Radiological Health Department cooperate in finding employment opportunities. Follow-up data show ninety-nine percent of all graduates working in occupations directly related to training received, and only one percent seeking additional schooling.

PROGRAM PROJECTIONS

Given the current staff and facility size, the enrollment level is felt to be near its ceiling. Departmental studies indicate a need to expand the curriculum and add three new options in addition to reinstating the Reactor Operator Technology program. The new options would be Radiological Instrumentation Technology, Radiological Quality Control, and Reactor Chemistry. These program additions would require a substantial increase in funding and faculty, which there is no provision for at this time.

COURSE DESCRIPTION

RHT 1000 Introduction to Radiation Technology - Orientation to radiation technology and skills used by radiological health technologists in radiation protection and control. (2 s.h.)

RHT 1110 Environmental Radioactivity - Origins of radioactive contamination. Radiation protection standards and environmental control. Measurement, detection, and prediction of environmental contamination associated with nuclear accidents, weapons testing, and contamination of terrestrial and cosmic origins. Guidelines for control of radioactive material as set by the Nuclear Regulatory Commission. (3 s.h.)

RHT 1321 Radiological Instrumentation Laboratory I - Bases for selection and use of various types of radiation detection instruments. (2.s.h.)

RHT 2120 Biological Effects of Radiation and Medical Applications - Hazards associated with radiation utilization. Biological, somatic, and genetic effects of ionizing radiation and the effects of acute and chronic radiation exposure. Review of diagnostic and therapeutic uses of radiation. (3 s.h.)

OCO 101 Work Experience - On-the-job training at appropriate medical, industrial, and/or research installations under the supervision of qualified radiological health specialists. (3 s.h.)

RHT 2310 Radiological Instrumentation Laboratory II - Continuation of RHT 1321. Instrumentation, laboratory techniques, and use of radioactive materials. Application of materials and instruments to areas of biology, chemistry, and industry. (2 s.h.)

RHT 2322 Electronics for Radiation Detection Instruments - Measurement techniques for low-level voltages and currents. Basic components and circuits in typical radiation detection instruments and their advantages respective of their sensitivity in high radiation fields. (3 s.h.)

RHT 2415 Radiation Physics I - A study of Physical Principals, Quantum mechanics, atomic and nuclear structure, radioactivity, interaction of radiation and matter, dosimetry, and radiation protection guides (3 s.h.)

RHT 2416 Radiation Physics II - A continuation of Radiation Physics I including studies in Neutron interaction and dosimetry, external radiation protection and calculations, waste disposal, shielding and evacuation of protective measures. (3 s.h.)

INSTITUTION: CHATTANOOGA STATE TECHNICAL COMMUNITY COLLEGE

PROGRAM: Nuclear Technology

DEPARTMENT: Division of Engineering Technologies

DEGREE: Associate of Science

CONTACT: Mr. Donald R. Stone
Associate Professor and Division Head
Life and Health Sciences
Chattanooga State Technical Community College
4501 Amnicola Highway
Chattanooga, Tennessee 37406
(615) 622-6262

PROGRAM DESCRIPTION:

PROGRAM STRUCTURE

This two-year program, first implemented in 1967, trains nuclear technicians who will be principally concerned with the detection, measurement and analysis of radiation. Graduates of the program are considered qualified to be members of research teams, health physics survey teams, radiochemical laboratory teams, and nuclear instrument manufacturing teams.

Extensive facilities are available to the program's faculty and students. These include three laboratories, a lecture room and a wide array of equipment. The faculty has developed its own laboratory manual.

PROGRAM REQUIREMENTS

Entrance to the program requires a high school diploma or the equivalent. The curriculum consists of one hundred and three quarter hours, thirty-three of which are in nuclear technology. In addition, twenty hours are required in mathematics, twelve in physics, eight in chemistry, and six in English. Specific courses are also required in the following areas: drafting, biology, public speaking, and computer science. Nine hours of electives in humanities are allowed, as well as four hours in technical fields. Students can take several options for electives and gain emphases in a variety of areas.

Any student at the institution may apply for merit scholarships, loans, part-time off-campus employment, work scholarships, or grants. Faculty of the Nuclear Technology program have considered developing an internship or work-study program. However, local industries have not expressed interest in cooperating in such an endeavor.

CURRENT FACULTY, STUDENTS, GRADUATES

There are two full-time faculty members with the program. Thirty students are currently enrolled, chiefly attending school full-time. The enrollment is on an upward trend. While the number of graduates had averaged eight to twelve in recent years, fourteen will graduate in 1978.

Every graduate has been successful in securing employment in the field. Approximately one-fourth of these persons become employed within the private sector. A high proportion of the remainder accept positions with the Oak Ridge National Laboratory. Officials state that each graduate normally is offered at least three jobs. Several students have continued their educations at four-year institutions following graduation.

PROGRAM PROJECTIONS

Faculty members would like to increase the student enrollment in this program to a point that at least fifteen persons are graduating per year. This would assist in making better use of faculty and facilities, and in supplying trained persons for the job market. Additionally, discussions are under way regarding developing a non-destructive technician training program. Graduates of such a program would work with quality control in the construction of nuclear and fossil fuel plants. Preliminary surveys have indicated that there is a local demand for personnel of this type. A possible need has also been identified for developing a nuclear medicine technician training program.

COURSE DESCRIPTION

NU 101 Nuclear Seminar - Provides an introduction to nuclear science by means of lecture and pertinent scientific films presenting an overall view of the entire curriculum. (1 q.h.)

NU 104 Radiation Protection and Radiological Health Administration - An overview of safety requirements associated with the handling of radioactive materials, and protection from radiation sources. Administration of radiological health practices including licensing requirements, permissible levels of exposure, radiation units and elementary dosimetry. (4 q.h.)

NU 144 Atomic Physics - A study of the atomic and electrical nature of matter, elementary particles, the nucleus, Bohr theory, absorption and emission of x-rays and spectra. (4 q.h.)

NU 154 Nuclear Physics - A study of the elementary theory of the nucleus, fundamental particles, natural and artificial radioactivity and nuclear reactions. (4 q.h.)

NU 204 Introduction to Nuclear Technology - Radiation induced ionization and its measurement via the electroscope. Concepts and the procedures for the measurement of exposure and dose

NU 204 (Cont'd) - units. Pipetting and other techniques required for sample preparation. (4 q.h.)

NU 214 Interaction of Radiation with Matter - The principles by which charged and uncharged particles interact with matter. Associated instruments which are based on the particular interaction principles studied. (4 q.h.)

NU 224 Radioisotopes I - The fundamentals of radioactivity, use of radioactive materials, radioactivity detection techniques, radiotracer procedures and application, regulation and licensing. Laboratory and counting room design and procedures, radiography and autoradiography techniques. Emphasis on appropriate laboratory applications to botany, biology, chemistry, physics and engineering. (4 q.h.)

NU 264 Health Physics - A study of radiation dosimetry, biological effects of ionizing radiation, radiation protection for occupationally exposed and special groups, and design of radioisotope laboratories. (4 q.h.)

NU 284 Radiation Physics Problems - Practical problems in radiation physics, radioactive decay, interaction, counting statistics, radiation units, regulations, radiation biology, instrumentation, dosimetry, personnel monitoring, waste disposal, air and water sampling, shielding, x-ray safety and radiography, and laboratory and facility design. (4 q.h.)

INSTITUTION: COLUMBIA UNIVERSITY

PROGRAM: Nuclear Engineering

DEPARTMENT: Mechanical and Nuclear Engineering

DEGREE:
Bachelor of Science (B.S.)
Master of Science (M.S.)
Nuclear Engineer
Eng. Sc. D.

CONTACT:
Dr. William W. Havens, Jr.
Director, Division of Nuclear Science and Engineering
School of Engineering and Applied Science
Seeley W. Mudd Building
Columbia University
New York, New York 10027
(212) 280-3284

PROGRAM DESCRIPTION:

PROGRAM STRUCTURE

Nuclear engineering programs were initiated at Columbia in 1951 and are offered at both the undergraduate and graduate levels. They are designed to give students knowledge of the technology involved in the utilization and application of nuclear fission and fusion. An environmental option is available at the undergraduate level but has attracted little attention in the five years it has been offered. Only two or three students have so far selected it.

Research funding for the program is provided by the federal Department of Energy. Facilities include a nuclear technology laboratory which was partially funded by the former Atomic Energy Commission, and the computer systems of the engineering school. Arrangements have also been made for the use of the Brookhaven and Oak Ridge National Laboratories when needed.

PROGRAM REQUIREMENTS

The admission requirements for the B.S. program include a high school diploma, recommendations from the student's principal and teachers, and the Scholastic Aptitude Test plus three achievement tests. It is also recommended that students have completed four years of high school english literature and composition, four years of math, two or three years of foreign language, three or four years of history and social studies, and two or three years of laboratory science.

Admission to the M.S. program includes a B.S. in nuclear, mechanical, chemical, or electrical engineering or in metallurgy, physics, or engineering mechanics, with an above average record. For admission to the Nuclear Engineer program an M.S. in nuclear engineering or any other engineering branch with a nuclear minor is required. Requirements for admission to the Eng.Sc.D. program include an M.S. degree or equivalent course work in nuclear engineering or physics or in mechanical or chemical engineering or metallurgy with a nuclear minor.

A B.S. degree requires a minimum of sixty-five credit points in the freshman and sophomore years and an additional sixty-five credit points in the junior and senior years, including at least twenty-eight points of nontechnical courses approved by the Dean. Requirements for the M.S. degree include at least thirty credit points beyond the B.S. level, including a minimum of eight points of electives. The Nuclear Engineer degree requires as a minimum, thirty credit points beyond the M.S. degree and a thesis concerned with a design problem. The emphasis in the Nuclear Engineer degree program is on the design and development aspects of nuclear engineering while the emphasis in the Eng.Sc.D. program is in the demonstration of original research ability. Requirements for the Eng.Sc.D. include at least thirty credit points beyond the M.S. degree. Additional requirements include twelve credit points must be obtained in N.E. 9800 - Doctoral Research Instructions, a doctoral qualifying exam, demonstration of a reading knowledge in two foreign languages in which there is significant technical literature, one of which must be Russian, German, or French, and a doctoral dissertation.

CURRENT FACULTY, STUDENTS, GRADUATES

Seven full-time faculty members participate in the program, six of whom divide their time equally between teaching and research and one researcher. The research funding is provided by the U.S. Department of Energy.

There are thirty-five full-time students currently enrolled in the undergraduate program and twenty-six full-time and twelve part-time students in the three graduate programs. About seventy-five percent of these students are from the New York City metropolitan area. No specific recruiting is done for the nuclear engineering program and it is expected that many students become aware of the program through informal contacts and the reputation of the program. Several students are receiving some form of financial assistance. At the undergraduate level, university scholarships are available and at the graduate level there are currently three students receiving teaching assistantships, three receiving research assistantships, and one receiving a fellowship.

Approximately seventy-five percent of the B.S. graduates go on to further training while of the remainder, about seventy-five percent find employment in the private sector and the other twenty-five percent work in government jobs. Of the graduates in the M.S. program, less than one-third continue their education and of all the graduate degree students going directly into employment, it is estimated that thirty percent work in the private sector, sixty percent in government, and the remaining ten percent go into teaching and research. Most students are placed in positions through contacts and referral by faculty members. The University placement service is somewhat helpful to undergraduates.

PROGRAM PROJECTIONS

No change in the program structure or number of faculty is anticipated. It is hoped however that a nuclear waste management course can be offered within the next couple of years.

COURSE DESCRIPTION

Introduction to Nuclear Science - An introduction to those aspects of the physics of the nucleus which are important to nuclear engineering. (3 s.h.)

Introduction to Nuclear Technology - The non-neutron aspects of nuclear technology and their interaction with the purely nuclear features. (3 s.h.)

Introduction to Design Projects in Nuclear Technology - This course examines design problems chosen from among those often encountered in the nuclear industrial field. (3 s.h.)

Nuclear Fuel Management - Overview of reactor types and fuel cycle, reactor core analysis (generation of group constants, fuel cell, assembly and core analysis), core depletion (Boron let-down curve, fuel depletion, fission products buildup, uranium and plutonium isotopes and assembly power-sharing and burnup), reactivity control and reactivity coefficients, hot channel factors, reactor startup tests, core follow, Pu recycle, core loading and fuel reshuffle, fuel cycle economics (safety considerations and waste management), spent fuel transport, fast and thermal breeder. (3 s.h.)

Radiation Shielding - Sources and biological effects of radiation. Primary interactions of radiations with matter. (3 s.h.)

Special Problems in Nuclear Science and Engineering - A series of individual offerings are made over a three or four year cycle. Among typical topics are fast reactors: core physics, fuel technology, safety, breeding, economics; environmental effects; containment, thermal effects, radioactive release, and others. (3 s.h.)

INSTITUTION: CORNELL UNIVERSITY

PROGRAM: Nuclear Engineering

DEPARTMENT: Nuclear Science and Engineering

DEGREE: Master of Engineering (M.Eng.)
Master of Science (M.S.)
Doctor of Philosophy (Ph.D.)

CONTACT: Dr. David Clark
Director, Ward Laboratory
Department of Nuclear Science and Engineering
Cornell University
Ithaca, New York 14853
(607) 256-1000

PROGRAM DESCRIPTION:

PROGRAM STRUCTURE

The nuclear engineering program at Cornell is designed to give students the basic principles of nuclear reactor systems with major emphasis on reactor safety and radiation protection and control.

Established approximately ten years ago, the program offers three graduate degrees: the M.Eng., M.S., and Ph.D. The M.Eng. program is intended as a terminal, professional degree program, but students may continue on into the Ph.D. program. Both the M.S. and Ph.D. programs are research oriented and students design their own programs. Nuclear engineering is interdisciplinary and admits students from a variety of undergraduate backgrounds.

A major supporting facility of the program is the Ward Nuclear Engineering Laboratory, located on campus. Included among the equipment here are two nuclear reactors. The program also has the use of the university's central computing system.

PROGRAM REQUIREMENTS

Admission to the M.Eng. program requires a baccalaureate degree from an accredited engineering program or its equivalent in an appropriate area of engineering or science. The recommended background includes an undergraduate degree in engineering, applied science, or physics, course work in modern physics, math, including advanced calculus, and thermodynamics.

Requirements for admission to the M.S. and Ph.D. programs generally include a baccalaureate or equivalent degree from a college or university of recognized standing.

The M.Eng. program is two-terms in length and includes thirty hours of graduate credit. Required courses treat reactor safety and radiation protection and control in depth and electives are available in radiation biology and physical biology. The requirements include courses in nuclear reactor theory, nuclear reactor engineering, low-energy nuclear physics, nuclear measurements laboratory, an engineering design project, two technical electives, and a math or physics elective.

There are no detailed course requirements for the M.S. and Ph.D. degrees and each student is permitted to plan his own program in consultation with faculty members of his Special Committee. A student in these programs may choose to major in nuclear engineering or nuclear science. Completion of a thesis is required.

CURRENT FACULTY, STUDENTS, GRADUATES

The program has three full-time and five part-time faculty members who divide their time between teaching and research. Research funding for the program is provided principally by the National Science Foundation and by the Electric Power Research Institute at Stanford University.

There are currently twelve students, all full-time, in the program. Few are career change students and no data are kept on whether students are in-state residents or not. The program does no specific recruiting, and generally has more applicants than it can accept. Student assistance is available in the form of fellowships, loans, and assistantships.

The program averages about seven graduates per year with some slight fluctuation. Virtually all students go directly from the program into employment and the majority work for private industry with reactor manufacuturers and engineering and consulting firms. The remainder find jobs with regulatory agencies and in teaching and research.

PROGRAM PROJECTIONS

There are plans to expand the program over the next three years to include courses on fusion technology and place more emphasis on radiation protection and reactor safety. An increase of approximately three faculty members will likely be required for this expansion.

ADDITIONAL INFORMATION

Program officials conduct a summer program for high school teachers from New York and Pennsylvania in nuclear science. This annual program receives funding support from the Energy Research and Development Administration (DOE).

COURSE DESCRIPTION

(the following is a partial listing of courses)

IP201 Nuclear Energy and the Environment - Fundamentals of nuclear radiations and their measurement and interaction with matter, the natural radiation environment, and sources of manmade radioactivity (5 weeks); radiation chemistry, radiation biology, somatic and genetic effects of nuclear radiation, movement of radioactive materials in the biosphere, and other topics. (3 s.h.)

IP609 Low-Energy Nuclear Physics - The nuclear interaction. Properties of ground and excited states of nuclei; models of nuclear structure; resonant and nonresonant scattering, absorption, and fission. (4 s.h.)

IP612 Nuclear Reactor Theory I - A first course in the physical theory of fission reactors. The fission process and the essential properties of neutron interactions with matter are described. (4 s.h.)

IP633 Nuclear Reactor Engineering - A selected set of topics representing the fundamentals of nuclear reactor engineering. (4 s.h.)

IP634 Nuclear Engineering Design Seminar - A group design study of a selected nuclear reactor system. Emphasis is on safety, siting, and radiation protection in the design of nuclear power systems. (4 s.h.)

IP651 Nuclear Measurements Laboratory - Laboratory experiments plus lectures on interaction of radiation with matter and on radiation detection, including electronic circuits. The student is expected to perform eight to ten experiments selected to meet the student's needs. Some stress is placed on independent work by the student. (4 s.h.)

INSTITUTION: HARTFORD STATE TECHNICAL COLLEGE

PROGRAM: Nuclear Engineering Technology

DEPARTMENT: Nuclear Technology

DEGREE: Associate in Science (A.S.)

CONTACT: Dale Robinson, P.E.
Nuclear Technology Department
Hartford State Technical College
401 Flatbush Avenue
Hartford, Connecticut 06106
(203) 527-4111

PROGRAM DESCRIPTION:

PROGRAM STRUCTURE

Hartford State Technical College's two year Nuclear Engineering Technology Program is the only technology program of its kind on the East Coast and possibly the entire United States. A broad understanding of the engineering applications of radioisotopes and ionizing radiation is the general goal of education to be provided to students. Studies include radiation safety, atomic and nuclear physics, health physics, and various applications of current instrumentation techniques. Students find jobs as industrail radiologists, instrumentation technicians, radio-chemistry technicians, health physics technicians, reactor operators, and research assistants.

Hartford State Technical College is accredited by the New England Association of Schools and Colleges, Inc. and the Connecticut Commission for Higher Education. The Engineers Council for Professional Development is the accrediting body for the Nuclear Technology Program. The College has a reputation in the New England areas as providing instruction in the civil, mechanical, and electrical technologies.

Available to students in the Nuclear Engineering Technology Program is an extensive laboratory which includes chemical equipment, scalers, rate meters, single and multi-channel analyzers, x-ray machines, and other equipment. The laboratory is recognized as providing more than enough instrumentation facilities to handle student needs.

PROGRAM REQUIREMENTS

In order to enter this program, prospective students must be vocational technical or high school graduates or possess a State Equivalency diploma. Students with no mathematics or science background must pass a pre-technical program. Students must also take the mathematics/science portions of the Engineering and Physical Science Aptitude test which is an admissions examination .

The Nuclear Engineering Technology curriculum requires two years of study broken into six quarterly periods. Each quarter contains a specified number of class and laboratory hours of credit. Included in the total of 119 quarter hours of credit are 102 class and 40 laboratory hours. Students may also take two additional electives during their last two quarters and these usually include further calculus if a student desires to continue on to an engineering bachelor's program for their third year.

Most of the students have part-time employment to supplement their educational costs and many receive Basic Educational Opportunity Grants. The College has relatively low tuition so financial aid is not normally a critical problem. Several hundred dollars is also available through the federal and state Work-Study Program.

CURRENT FACULTY, STUDENTS, GRADUATES

Only one faculty member has a full-time teaching position within this program. The Nuclear Technology Department offers twelve courses for its students and supplements these with courses offered by other departments.

There are currently (Fall, 1977) twelve students enrolled in the program. Approximately nine to ten students graduate annually from the program,on the average. The trend in enrollment has been declining and nine students including two females graduated from the program in June, 1977. A small percentage of students enter the program on a career change basis and those that do often come with an electronics technology background.

Program officials estimate that approximately sixty percent of the graduates continue onto a Bachelor degree program and those doing so are more likely to work in the field as a nuclear technologist. Many continue to nuclear engineering programs offered by the University of Lowell, the University of Hartford, and the Rensselaer Polytechnic Institute. About sixty-five percent of the program's graduates have found employment in the field while thirty percent have found jobs in a related field. Many of those finding jobs in a related field have found positions as nuclear engineers with firms such as United Aircraft in which they utilize instruction offered by the program but which are not specifically nuclear engineering. Only about five percent of the graduates have found jobs in an unrelated field. It is estimated that the graduates have been most successful in finding positions in the private sector.

The College maintains a placement service to assist students and alumni in obtaining jobs. Employers have visited the college interviewing prospective employees from organizations, as the Tennessee Valley Authority and the U.S. Navy at Newport News. At times employers have called the Department requesting interviews with students but the students have had much more success arranging their own contacts.

PROGRAM PROJECTIONS

Due to a trend of decreasing enrollment, the Nuclear Engineering Technology may eventually suspend its A.A.S. degree program. In the past, several courses have been combined and environmental protection courses have also been offered to enable students to become more employable. The program may eventually develop an energy related curriculum to replace the Nuclear Engineering Technology program. However, so far the program has been able to maintain its present emphasis and no change may actually occur within the next five year period. Also, it is not expected that any additional faculty members will be recruited due to the declining enrollment trend.

COURSE DESCRIPTION

NT 112 Nuclear Materials - This course consists of an introduction to the vocabulary and the processes involved in the preparation of engineering materials for use in the nuclear industry. (2 q.h.)

NT 215 Fluid Mechanics - This course includes a review of the basic properties of fluids and the topics of pressure forces, center of pressure, and interpretation of reading from various kinds of pressure measuring devices. (4 q.h.)

NT 230 Nuclear Physics - A study of the nuclear aspects of modern physics is covered with emphasis on nuclear forces, binding energies, nuclear structure, the phenomena of fission, radiation, and the statistics of counting. (5 q.h.)

NT 240 Radiation Health and Safety - A study of the effects of nuclear radiation on man and his environment is the subject of this course, plus measures necessary for the protection of humans from these effects. (4 q.h.)

NT 250 Nuclear Instruments and Applications 1 - This course is a study of the basic properties of various detection devices used to measure the interaction of radiation with matter. (5 q.h.)

NT 251 Nuclear Instruments and Applications II - This course includes the use of digital computers in nuclear calculations. (5 q.h.)

NT 270 Nuclear Reactors - This is a survey course intended to give the student an over-all picture of nuclear power plant systems, materials, fueling, and other relevant materials. (4 q.h.)

NT 340 Radiation Hazards and Instrumentation - This course covers elementary atomic theory, ionization, x-rays, control of hazards, nuclear fission and fusion, radiation detection equipment, and others. (3 q.h.)

INSTITUTION: HARVARD UNIVERSITY SCHOOL OF PUBLIC HEALTH

PROGRAM: Environmental Health Sciences

DEPARTMENT: Environmental Health Sciences

DEGREE: Master of Science (S.M.)
Doctor of Science (Sc.D.)

CONTACT: Dr. Dade W. Moeller
Head, Department of Environmental Health Sciences
Harvard University School of Public Health
665 Huntington Avenue
Boston, Massachusetts 02115
(617) 732-1169

PROGRAM DESCRIPTION:

PROGRAM STRUCTURE

The Environmental Health Sciences program offers a multidisciplinary approach to the study of the effects of environmental pollutants. This program has developed from an industrial hygiene curriculum which began in 1918 and a radiological health program followed in 1946.

Five specialized programs are offered: Air Pollution Control, Environmental Health Management, Industrial Hygiene, Medical Radiological Physics, and Radiological Health. Students take basic courses, common to all five areas, and then normally concentrate in one area. Program requirements are flexible and it is possible for a student to plan a program in two or more of the specializations.

A principal support facility for the program is the Kresge Center for Environmental Health which includes an air cleaning laboratory. Computer facilities are also available through the Harvard Computer Center.

PROGRAM REQUIREMENTS

Program admission for the School of Public Health requires acceptable work in an undergraduate program and three letters of recommendation. Requirements for the environmental health sciences program stipulate that the undergraduate degree should be in math, chemistry, physics, biology, or engineering with a strong background in three of the first four subjects.

S.M. programs may be completed in one or two years. For a one year program, a student must have a master's degree in one of the appropriate sciences or approved prior education and work experience in a related area. A minimum of forty credit units are required for the one year program and at least eighty credit units are required for completion in two years. In addition, the two-year program requires that at least ten credits in the second year be devoted to an appropriate research or related study, followed by a written report. Although students may register for courses at other Harvard graduate schools and at M.I.T., at least fifty percent of the program must consist of courses offered within the School of Public Health.

The Doctor of Science degree requires a minimum of two years in residence while enrolled in the program, and normally takes two to four years to complete. Qualifying examinations at both the department and school level, as well as a thesis representing original research,are also required.

CURRENT FACULTY, STUDENTS, GRADUATES

Program faculty consists of nine members, seven full-time and two part-time. About seventy percent of faculty time is devoted to research and the remainder to teaching. Funding for research is currently provided by EPA, the Department of Energy, and the Nuclear Regulatory Commission.

The program has a current enrollment of 43 full-time and 11 part-time. Several students have used the program as a means for making a career change, particularly from chemistry. Approximately forty percent of the students are in-state residents. Formal recruitment is achieved through advertising in professional journals. Many students enroll, however, after taking short courses offered by the department or through the referral by program alumni. Most students have some form of financial assistance, primarily training grants and fellowships. Several students are also employed part-time.

An average of thirteen students graduate from the S.M. program each year and the Sc.D. program averages two graduates per year. A majority of graduates find employment in private industry or with consulting firms. Others are employed by government agencies or academic institutions. Approximately twenty percent continue their education. Graduates normally find jobs through individual counselling by faculty members, and posted notices of job opportunities.

PROGRAM PROJECTIONS

Officials expect enrollment to increase to an annual average of sixty students within another year. No increase in faculty would be necessary.

ADDITIONAL INFORMATION

Program officials conduct twelve annual short courses in environmental health through the continuing education program. A total of about four hundred students attend these courses each year. A biennial International Air Cleaning Conference is also conducted by program personnel.

COURSE DESCRIPTION

(the following is a partial listing of courses)

Environmental Health Interdepartmental 201a, 201b Principles of Environmental Health - This course reviews the more important environmental health problems facing society. Topics in areas "a" and "b" cover different areas, and may be taken separately. (2.5 s.h.)

Environmental Health Interdepartmental 202d Community Environmental Health Management - A Computer-Simulated Gaming Experience - This is a computerized game which simulates a metropolitan environment by including basic data on such factors as air pollution characteristics, employment, land use, and public services. (2.5 s.h.)

Environmental Health Sciences 202b Departmental Seminar - The purpose of these seminars is to supplement the formal course work of the Department by bringing to the attention of students a wide range of topics of contemporary interest in air pollution control, industrial hygiene, radiological health, and environmental health management. (1 s.h.)

Environmental Health Sciences 252a, 252b Environmental Control - The first half of this course centers on the design and evaluation of industrial ventilation systems for the control of toxic contaminants released into the workplace through industrial operations and processes. The second half is designed for environmental health specialists responsible for evaluation and control of noise hazards. (2.5 s.h.)

Environmental Health Sciences 261a, b Community Air Pollution - This course is designed for engineers, chemists, and physicians interesetd in air pollution control. (5 s.h.)

Environmental Health Sciences 271a, b Introduction to Radiation Protection - This course covers laboratory, industrial, and environmental sources of radiation; the interaction of ionizing particles with matter; and other topics of current interest. (5 s.h.)

Environmental Health Sciences 273 c,d. Advanced Topics in Radiation Protection - This course covers the physical principles and mathematical analyses utilized in the evaluation and control of radiation hazards. (5 s.h.)

INSTITUTION: KANSAS STATE UNIVERSITY (KSU)

PROGRAM: Nuclear Engineering

DEPARTMENT: Nuclear Engineering

DEGREE: Bachelor of Science (B.S.)
Master of Science (M.S.)
Doctor of Philosophy(Ph.D.)

CONTACT: Dr. N. Dean Eckhoff
Dr. Richard E. Faw
Department of Nuclear Engineering
Kansas State University
Manhattan, Kansas 66506
(913) 532-5624

PROGRAM DESCRIPTION:

PROGRAM STURCTURE

The curriculum in Nuclear Engineering at Kansas State University is both diverse and flexible for undergraduates and graduate students alike. The B.S. degree--the first such Engineer's Council for Professional Development (ECPD) accredited program--is designed to prepare students for professional positions in industry, government, and private practice. Through technical electives, the student may organize a program suited to his/her particular needs and interests. Undergraduate students take engineering science courses in materials, thermodynamics, particle and continuum dynamics, electronics. circuit theory, and economics. These courses prepare them for more sophisticated courses in nuclear reactor design principles; neutron and charged particle interactions; radiation detection, protection, and effects on materials; nuclear fuel management; industrial isotope applications; nuclear power cycle thermodynamics and siting; and regulation and environmental impact assessment of nuclear power plants. Graduate students pursue individualized plans of study that balance subject matter from other fields with specific research interests and needs of each student.

Facilities available to KSU students and faculty are extensive. The University operates the following laboratories: 250-kilowatt TRIGA Mark II reactor, Radiation Shielding Facility on a 180-acre remote site whith full scale house and other experimental shielding text structures, Neutron Activation Analysis Laboratory, Radioisotope Application Laboratory, Shock-Tube Laboratory, Environmental Monitoring Laboratory, and Radiation Effects and Fuel Processing Laboratory.

In addition to the university cooperative work program for undergraduates, the Department of Nuclear Engineering conducts workshops for high school teachers and sponsors tours with associated lectures through its facilities. Limited reactor operating time can be provided to college and university groups for the performance of reactor experiments. All noncommercial service irradiations can usually be accommodated; and complete or partial, quantitative or qualitative neutron activation analysis can be performed either by outside users or by Department of Nuclear Engineering personnel.

The Department of Nuclear Engineering is currently heading a project to develop educational materials on the nuclear fuel cycle. Research funding for the past three years totals $943,074; sponsoring agencies include the Energy Research and Development Administration, National Science Foundation, State of Kansas, Kansas Gas and Electric, Northwest College and University Association for Science (NORCUS), Oak Ridge Associated Universities, Nuclear Regulatory Commission, Ozark Regional Commission, Radiation Research Associates, Northern Natural Gas, and American Chemical Society.

PROGRAM REQUIREMENTS

The B.S. degree in Nuclear Engineering requires 131 semester hours to complete. For admission to graduate work, a student must have a bachelor's degree from an approved institution and adequate preparation in mathematics and the physical sciences. Candidates for the master's degree can pursue one of two plan-of-study options: (1) a minimum of thirty semester hours of graduate credit including a master's thesis of six to eight semester hours, or (2) a minimum of thirty semester hours of graduate credit in course work only but including evidence of scholarly effort such as term papers, production of creative work, and so forth. The choice of option is based on the recommendation of the student's supervisory committee, and most students follow the first plan. The Ph.D. degree requires completion of sixty hours of coursework, thirty hours of research, and the dissertation.

CURRENT FACULTY, STUDENTS, GRADUATES

The faculty time loads in the Department of Nuclear Engineering are divided 7.1 for teaching and 1.1 for research; there are eight full-time and two part-time staff members. Enrollment figures indicate 100 undergraduate majors, 15 master's students, and 10 doctoral candidates. Numbers of graduates annually vary by degree and are relatively stable. Over the past three years (75/76/77), 17/10/23 B.S., 5/5/5 M.S., and 4/3/0 Ph.D. diplomas have been awarded. Graduates typically enter the engineering field in the areas of design, research, management, and consulting or they choose related work in law or medicine; an overwhelming 90 percent opt for employment in the private sector.

In addition to the undergraduate cooperative work experience available to students, sources of financial support include state-funded graduate research contracts, fellowships (International Atomic Energy Agency and others when available), traineeships (when available), and employment on contracted work in the department.

PROGRAM PROJECTIONS

In existence since 1959, the program in Nuclear Engineering at Kansas State University should not change radically in the near future. Faculty contend that the current curriculum meets foreseeable training needs for the next decade, although there is a need for more traineeships. No staff members, aside from one or two temporary faculty, are to be added in the next five years. Any revisions in the program will be toward providing students with a more comprehensive view of energy.

COURSE DESCRIPTION

Undergraduate credit:

580 110 Nuclear Engineering Concepts - This first course in the Nuclear Engineering curriculum acquaints freshman students with the professional activities and responsibilities of nuclear engineers. It presents this information through lectures, recitations, and laboratory demonstrations. (2 s.h.)

580 116 Nuclear Engineering Seminar - Introduction to professional nuclear engineering. Student career planning. (1 s.h.)

580 315 Introduction to Nuclear Engineering Analysis - Introduction to analytical, statistical, and numerical analysis as applied to nuclear engineering, including computer programming. (3 s.h.)

580 325 Elements of Nuclear Engineering - Nuclear reactions, nuclear energy releases, ionizing radiation, radiation attenuation; introduction to nuclear reactor concepts of criticality, multiplication factor, period, reactivity, neutron lifetime, fission product poisoning; introduction to reactor instrumentation and control, standards for protection against radiation, health physics, nuclear safety, licensing, survey and monitoring instrumentation, instrument calibration, calculation of dose, dose rates, determination of maximum permissible concentrations and body burdens. (3 s.h.)

580 410 Introduction to Nuclear Engineering - A course to acquaint non-nuclear engineers with introductory aspects of nuclear engineering; a study of nuclear reactions, reactor core calculations, reactor safety and dynamics, shielding, fuels, waste disposal, electric power generation and radioisotope applications engineering. (3 s.h.)

580 490 Neutron and Particle Interactions I - Engineering approach to the classical mechanics of the interaction of neutrons and other radiation with matter, production and detection of neutrons and other types of nuclear radiation. (2 s.h.)

Undergraduate and graduate credit in minor field:

580 500 Applied Nuclear Engineering Analysis - Methods and applications of analytical, statistical, and numerical analysis as applied to nuclear engineering including computer programming. (3 s.h.)

580 510 Neutron Activation Analysis - Basic nuclear properties, neutron flux characteristics, nonreactor neutron sources, radiochemical separations, radiation detectors and counting statistics, gamma-ray spectroscopy, analysis of gamma-ray spectroscopic data, case studies. (3 s.h.)

580 511 Radioisotope Applications Engineering - A laboratory course designed to familiarize the student with experimental parameters of importance in the design of engineering systems which make use of radioisotopes. (2 s.h.)

580 515 Nuclear Engineering Materials - An investigation of the properties and behavior of structural materials, fuels, and components in nuclear radiation environments. (2 s.h.)

580 555 Nuclear Reactor Fundamentals - Introduction to reactor cooling. Analysis of power cycles. Basic reactor thermal design. (3 s.h.)

Undergraduate and graduate credit:

580 613 Nuclear Fuel Cycle - A course to familiarize the student with uranium conversion procedures, enrichment techniques, nuclear fuel burnup, spent fuel transport, reprocessing of spent fuel, fission product disposal methods, and economics of the nuclear fuel cycle. (3 s.h.)

580 615 Nuclear Materials Control and Safeguards - The management, control, measurement, accounting, and protection of nuclear fuel and strategic materials in the nuclear fuel cycle. (3 s.h.)

580 630 Applied Reactor Theory - Theory of diffusion and slowing down of neutrons with application to critical and sub-critical nuclear reactors. Measurement of various reactor physics parameters. (4 s.h.)

580 640 Reactor Operations Planning - Licensing, nuclear safety, and reactor operations. Measurement of nuclear reactor parameters. (2 s.h.)

580 650 Environmental Radiation - Radionuclides and ionizing radiation in the environment of natural and artifical origin. Biological effects of radiation. Detection and measurement of environmental radiation. Licensing and regulation pertaining to environmental radiation. (3 s.h.)

580 655 Radiation Protection Engineering - Principles of radiation protection. Radiation shielding, radiation dosimetry, and administrative aspects of radiation protection. Special applications in nuclear plant design, fuel transportation, and fuel reprocessing. (3 s.h.)

580 675 Neutron and Particle Interactions II - Engineering approach to the quantum mechanics of the interaction of neutrons and other nuclear radiations with matter; theoretical methods for the evaluation of nuclear reaction cross sections required for engineering applications. (2 s.h.)

580 692 Nuclear Reactor Technology - Thermal and neutronic design analysis of nuclear reactors. Nuclear quality assurance. Safety analysis reports. (3 s.h.)

580 695 Nuclear Reactor Laboratory - Experimental investigation of thermal and hydraulic characteristics of nuclear reactors. (1 s.h.)

580 699 Constructive Uses of Nuclear Explosives - Characteristics and effects of nuclear explosives; Plowshare tests; industrial uses of nuclear explosives; scientific applications of nuclear explosions. (3 s.h.)

580 708 Nuclear Fuel Processing Laboratory - Experimental investigation of the methods and principles of separation and purification as they apply to the production and recovery of nuclear fuel and materials. (1 s.h.)

580 715 Radiation Shielding - Introduction to important sources of radiation, kernel concepts, and application of diffusion and ray theory to shielding calculations, applications principally in the field of stationary nuclear reactor shielding. (3 s.h.)

580 720 Nuclear Systems Analysis - Introduction to nuclear reactor kinetics and simulation. Linear stability of reactor systems. Noise analysis. Application of hybrid computers to nuclear systems analysis. (3 s.h.)

580 750 Direct Energy Conversion - Principles and analysis of direct conversion phenomena, with special emphasis on direct conversion of nuclear energy including thermoelectric, thermionic, photovoltaic, magnetohydrodynamic and electrochemical processes. (3 s.h.)

580 761 Radiation Detection and Measurement - Theory of detection of nuclear radiation. Measurement devices and systems. Applications to radiation dosimetry and spectroscopy, and instrumentation systems for nuclear reactors.

580 762 Nuclear Instrumentation - Design and analysis of nuclear instrumentation. Application to nuclear reactor control, radiation dosimetry and nuclear spectroscopy. (4 s.h.)

580 772 Radiation Effects on Materials I - General theory of radiation damage to solids. Specific effects of radiation on nuclear reactor components and materials of construction. Applications to nuclear reactor design. (3 s.h.)

580 774 Radiation Effects on Materials II - General theory of radiation effects on liquids and gases. Principles of radiation chemistry, photochemistry, and biophysics. Medical, agricultural and industrial applications. (3 s.h.)

580 791 Controlled Thermonuclear Reactions I - Principles of controlled thermonuclear processes; fuel cycles; energy-balance considerations; magnetic and inertial confinement; plasma instabilities; plasma heating; neutronics; radiation damage and materials problems; design of experimental power reactors and power-reactor systems. (3 s.h.)

580 795 Separation of Nuclear Fuels - A graduate level course investigating the chemical properties, the methods of separation, purification and reprocessing of uranium, thorium and plutonium. (4 s.h.)

Graduate credit:

580 806 Neutronics I - Particle transport, theories of diffusion, numerical analysis of diffusion, transient core analysis. (3 s.h.)

580 808 Neutronics II - Perturbation theory, core neutronic design, spatially dependent kinetics, reactor control. (3 s.h.)

580 847 Nuclear Power Engineering I - Principles of hydraulic and thermal analysis for nuclear power reactors. Advanced core design. (3 s.h.)

580 851 Nuclear Engineering Laboratory - Reactor kinetics, reactor noise analysis determinations of B/I, reactor power calibration, auto and cross-correlation techniques, pulsed neutron measurement, radiation shielding, radiation effects, activation analysis, neutron diffraction, and heat transfer. (2 s.h.)

580 860 Advanced Topics in Nuclear Engineering - A presentation of various special topics covering advanced nuclear engineering specialities. (var. s.h.)

580 890 Nuclear Engineering Colloquium - Presentation and discussion of progress reports on research, special problems, and outstanding publications in nuclear engineering and related fields. (1 s.h.)

580 925 Transport Theory I - Principles of transport theory, approximation theory, numerical transport algorithms, gamma ray transport. (3 s.h.)

580 926 Transport Theory II - Advanced approximation theories, transport code development. (3 s.h.)

580 947 Nuclear Power Engineering II - Nuclear system analysis and design with computational considerations. System safety analysis. (3 s.h.)

580 970 The Interaction of Radiation with Matter - Classical and quantum theories of the interaction of radiation with matter. Energy and charge transfer processes. Applications to nuclear reactor theory, radiation shielding, and nuclear instrumentation. (3 s.h.)

580 991 Controlled Thermonuclear Reactions II - Continuation of N.E. 791. Collisionless plasmas; theory of plasma waves and instabilities; plasma diagnostics, experimental approaches. Other topics of current interest. (3 s.h.)

INSTITUTION: MASSACHUSETTS INSTITUTE OF TECHNOLOGY

PROGRAM: Nuclear Engineering

DEPARTMENT: Nuclear Engineering

DEGREE: Bachelor of Science (S.B.)
Master of Science (S.M.)
Nuclear Engineer
Doctor of Science (Sc.D.) or Doctor of Philosophy (Ph.D.)

CONTACT: Dr. Norman C. Rasmussen
Head, Department of Nuclear Engineering
Massachusetts Institute of Technology
Cambridge, Massachusetts 02139
(617) 253-3802

PROGRAM DESCRIPTION:

PROGRAM STRUCTURE

Nuclear engineering at M.I.T. is composed of four degree programs: the S.B., S.M., Nuclear Engineer, and Sc.D. or Ph.D. The graduate programs have been in existence since 1958 and the undergraduate program began in 1975-76 school year.

The undergraduate program is somewhat interdisciplinary in that students are encouraged to take courses from several departments in order to gain broad exposure to engineering and the sciences. Students have considerable flexibility in planning their programs and may either specialize in a particular aspect of nuclear engineering or obtain a broad-based background.

Graduate programs are also flexible, allowing students to plan their own programs of study. Most, however, fall into one of six fields of study that are offered; reactor physics, reactor engineering, nuclear fuel and power management, applied plasma physics, nuclear materials engineering, and applied radiation physics. The S.M. program is one year in length and prepares students for careers as nuclear engineers or for more advanced study. A Nuclear Engineer degree is a two-year professional degree, training students in the practical aspects of nuclear engineering. A Ph.D. program generally takes three to five years to complete and prepares students for advanced research in the field.

Program support facilities include a nuclear reactor, nuclear research labs, and the computer facilities of the MIT Information Processing Center. Students and faculty also have the opportunity to use the facilities of national laboratories such as Brookhaven.

PROGRAM REQUIREMENTS

Requirements for entry into the S.B. program include a high school diploma with a minimum of units (one year of study) taken in specified subjects, including four units of English, two units of algebra, one unit each of plane geometry, physics, and chemistry, and one-half unit of trigonometry. Applicants are required, in addition, to take the Scholastic Aptitude Test and three achievement tests and to have a personal conference with a member of the M.I.T. Educational Council.

Master's and Engiener degree admission requirement include a bachelor's degree or equivalent from an acceptable college, university, or tehcnical school along with demonstration of ability to accomplish a program of study and research. The Sc.D. and Ph.D. programs normally require a student to meet the qualifications for a Master's degree before admission is granted.

Degree requirements for the S.B. include the completion of sixty credit hours in science requirements and seventy-two hours in humanities, arts, and social sciences. After completing these, the students select courses in basic engineering principles including thermodynamics, fluid flow, heat transfer, strength of materials, and computer modeling. In the final two years, a student concentrates in nuclear engineering subjects which include a design course and a thesis required for the degree.

Minimum requirements for the M.S. degree are two semesters of full-time graduate course work plus a thesis. The Nuclear Engineer degree requires four full time semesters of graduate course work, including a thesis concerned with engineering, analysis, engineering design or construction of nuclear facility or device. A student who meets the requirements for the Engineer degree is simultaneously approved for the S.M. degree by the department. The Sc.D. and Ph.D. degree are awarded interchangeably and the student may select either one. Requirements include a general examination in one of the six fields of study offered and an original research investigation which constitutes a contribution of permanent value to science and technology. No time limit is required for completion of the program, however, most students require three to five years.

CURRENT FACULTY, STUDENTS, GRADUATES

There are currently twenty-five faculty members in the Nuclear Engineering Program, and all are involved in both teaching and research. Research funding is available from a number of sources, primarily the Energy Research and Development Administration (DOE) and the Electric Power Research Institute.

A total of thirty students are enrolled full-time in the undergraduate program and one hundred and fifty full-time students are in the graduate program. The program does attract a few career-change students, primarily physicists. Although no records are kept on ratios of in-state and out-of-state students, approximately one-third of the program enrollment is composed of foreign students. The only recruiting done, is through the distribution of brochures to other colleges and universities. Most students, expecially at the graduate level, are receiving some form of financial assistance. This currently includes twenty three teaching assistantships, forty-four research assistantships, nine ERDA traineeships, and various other government (domestic and foreign) and private industry fellowships, traineeships and support.

In 1976, thirty-nine S.M. degrees were awarded, along with seven Nuclear Engineer, and twenty-four Sc.D. or Ph.D. degrees. All of these figures represent an increase over previous years and is indicative of the increasing interest in the program. The S.B. program just began in the 1975-76 school year and no figures are available concerning graduates. Of the total number of graduates, about one-third find employment in private industry. Another twenty percent work in government positions, mostly military. Approximately fifteen percent are employed by foreign governments and another fifteen percent go on to further study. The remainder generally work for national nuclear labs in research positions or go into teaching. The primary methods of finding employment are through faculty contacts or the M.I.T. placement service.

PROGRAM PROJECTIONS

With the addition of the undergraduate program in 1975, no further expansion in program or faculty is anticipated for the next several years.

ADDITION INFORMATION

The Nuclear Engineering Department offers a summer program, primarily for industry, on nuclear power reactor safety.

COURSE DESCRIPTION

22.04 Radiation Effects and Uses - Current problems in science, technology, health and environment which involve radiation effects and their utilization. Material properties under nuclear radiations. Medical and industrial applications of radioisotopes. Radiations and lasers in research. Radioactive pollutants and demographic effects. (2 s.h.)

22.08J Energy - Energy from a holistic point of view: provision, rational utilization and conservation, regulation, environmental effects, and impact on other societal sectors. Resources of petroleum, natural gas, coal, nuclear and other energy forms. Technologies of providing energy from these forms. Utilization of energy in various sectors: transportation, industrial, commercial, and domestic, including expecially opportunities for increased efficiency and energy conservation. Regulatory tax, and other institutional arrangements that affect production and use patterns. Environmental costs and opportunities associated with exercising various energy strategies, both existing and proposed. Domestic and international political, strategic, and economic implications. (3 s.h.)

22.37 Environmental Impact of Power Production - An assessment of the various environmental impacts of producing thermal and electric power with currently available thecnology. Impacts compared throughout both the fossil and nuclear fuel cycles. Topics include fuel resources and extraction, power station effluents, waste heat disposal, reactor safety, and radioactive waste disposal. (3 s.h.)

22.80 National Socio-Technological Problems and Responses - A subject designed to acquaint the student with large socio-technological problems and our capabilities regarding them, in ways beyond discipline oriented research. The structure and content of national problems; connectivity between problems and sectors. Review of present organizations at the working level (universities, national laboratories, industrial laboratories, etc.) the extent to which they relate to the decision-making levels, and the extent to which they match or mismatch their programs to the true scale of problems. Recent efforts to make new organizations or to re-orient present ones. Recent debates, programs, and proposals related to energy and the environment used as particular examples. (3 s.h.)

22.81 Energy Assessment - An introduction to the broad field of energy, including technological, social, environmental, economic, and political aspects. Energy provision, transformation, and utilization. Development of energy options for the future, and anlayses of present regional, national, and international energy programs. Intended for graduate students entering specific energy fields or in which energy is important, and who desire a holistic overview. (3 s.h.)

22.913 Graduate Seminar in Energy Assessment - Primarily designed as a communication medium among students conducting research in energy related areas, and as means for obtaining critical evaluation of their ongoing research work. Covers topics ranging from technological comparisons to environmental, social, resource, and political impacts, depending on current student and faculty interest. (2 s.h.)

INSTITUTION: MEMPHIS STATE UNIVERSITY

PROGRAM: Radiation Technician Training Course

DEPARTMENT: Center for Nuclear Studies

DEGREE: Continuing Education Units and
Certificate of Completion

CONTACT: Dr. D. W. Jones, Director
Center for Nuclear Studies
Office of Public Service and Continuing Education
Memphis State University
Memphis, Tennessee 38152
(901) 454-2687

PROGRAM DESCRIPTION:

PROGRAM STRUCTURE

The radiation technician training course is in the developmental stage within the Center for Nuclear Studies, and the first pilot course is planned for February of 1978. It is designed to train persons to be radiation technicians, or assistants to health physicists in nuclear facilities. The Center also offers operator training in nuclear reactor fundamentals, which is discussed in the Energy volume of this report.

The Center for Nuclear Studies has been operational since July of 1974. Its activities are chiefly supported by industrial training contracts, although some state and federal funds have been used for specific purposes. The Center pursues applied research in conjunction with the university, and is prepared to carry out design studies and to work in component development. The Center is viewed as a positive link between the university and the industrial community.

This course is being structured to meet the requirements of the Nuclear Regulatory Commission (NRC) for radiation technician training courses.

PROGRAM REQUIREMENTS

This course will be offered primarily at industrial plant sites for training of radiation technicians, and may be offered on campus in appropriate instances for specific groups. Each course will last six weeks, with thirty-five to forty hours of instruction each week; eight modules will comprise the course.

At least two quizzes will be given to students each week, and a two-hour formal examination given for every thirty-five hours in class. Records will be kept daily on the progress of all trainees, which will be submitted to employing utilities for review. Private consultation and tutoring will be arranged for students who fall behind schedule.

There will be no formal prerequisites for a utility employee or other potential student for entrance into the program. Officials feel, however, that it is important that participants have had a high school education or the equivalent, with strong background in mathematics and physics. The Center offers a testing and screening program to assist utilities in selection of employees who are likely to succeed in the program. An educational specialist and an industrial psychologist carry out the testing and screening program.

The Center has developed all of its own curriculum materials for this course, and will carry out ongoing evaluations of these materials and test questions. As with the nuclear reactor fundamentals course, a test question bank will be maintained, and records kept on the usage of each question in tests. The quality of each question will be judged based upon student responses.

CURRENT FACULTY, STUDENTS, GRADUATES

The six instructors of the Center for Nuclear Studies who teach the nuclear reactor fundamentals course will also provide instruction in the radiation technician training course. These persons have had six to fifteen years of experience working in nuclear facilities.

Nominal class size is six or eight because of the amount of individualized instruction that will be required, and because of the extensive use of laboratory facilities. Faculty members will attempt to assist those not already employed with utilities in finding employment in the radiation field.

PROGRAM PROJECTIONS

Whether curriculum changes will be made in the future depends in part upon NRC regulations and on outcomes of the Center's on-going self-review process. The future number of courses offered and faculty needs are entirely contingent upon the demand for the course by the nuclear industry, and the number of students who enroll.

COURSE DESCRIPTION

(Descriptions are based upon a preliminary draft of the course outline)

Module 1 Introduction to Radiation Safety - (not yet developed at the time of the interview).

Module 2 Radiation Physics - Topics include atomic and nuclear physics, radiation interaction with matter, reactor principles, crud, and measurements and units.

Module 3 Principles of Radiation Detection - Topics include gas filled detectors, charged particle and electromagnetic radiation detection, gamma spectrometry, neutron detection, instruments and application, and special applications.

Module 4 Regulations - Topics include regulatory agencies, radiation worker and non-radiation worker personnel exposure limits, transporting regulations, and radiation areas and control.

Module 5 Biological Effects of Radiation and Exposure Control - Topics include biological effects of radiation, estimation of exposure (dose), and exposure control.

Module 6 Radioactive Contamination and Waste Disposal - Topics include radioactive contamination (source, types, control), and waste disposal (liquid, gaseous and solid wastes).

Module 7 Environmental Monitoring Systems - Topics include background radiation, monitoring at plant sites, air sampling, water sampling, biological sampling, chemical and radiochemical analysis of environmental samples, and power plant monitoring procedures.

Module 8 Records, Reports and Administration - Topics include records of personnel exposure, surveys, waste disposal; reports of personnel exposure and radioactive materials; visitor and contractor personnel records and reports; personnel training; emergency planning and preparations.

INSTITUTION: MISSOURI SOUTHERN STATE COLLEGE (MSSC)

PROGRAM: Radiologic Technology

DEPARTMENT: Division of Technology

DEGREE: Associate of Science in Radiologic Technology

CONTACT: Mr. James K. Maupin, Dean
Division of Technology
Missouri Southern State College
Newman and Duquesne Roads
Joplin, Missouri 64801
(417) 624-8100, Ext. 272

PROGRAM DESCRIPTION:

PROGRAM STRUCTURE

Missouri Southern State College's Associate of Science degree in Radiologic Technology prepares a student to become a registered technologist upon passing the American Registery Examination. As evidence of MSSC's quality of preparation, no student to date has failed this certifying exam. The intensive 24-month curriculum is operated in cooperation with the staff of the Radiology Department of St. John's Medical Center in Joplin, Missouri. The program is approved by the Council on Medical Education and Hospitals of the American Medical Association (AMA) and follows those curricular guidelines established by this body. An advisory committee of 12 community members also oversees the program, assesses periodically its direction and quality, and recommends changes.

The program, which began in 1969, trains students for a variety of jobs--as clinical technicians, supervisors in special procedure areas (surgery, fluoroscopy, etc.), and industrial technicians. Students learn through one-on-one training sessions with hospital technicians and by using the facilities and equipment available at St. John's. Not only are the facilities outstanding, according to MSSC faculty, but the medical center underwrites the program's staff and director and makes its educational materials available to the students.

All students attend one major convention (cost **is** included in tuition) to gain a greater conception of their total field. If a student chooses, the Radiologic Technology degree can be linked with coursework in Business Management, thus providing additional job-placement flexibility.

PROGRAM REQUIREMENTS

The 24-month program includes 2,400 clock hours of clinical work and radiology lectures. A total minimum of 62 semester hours must be completed including 24 general education hours in basic skills, behavioral and social sciences, humanities, fine arts, natural sciences, and health and physical education. To enter the program, students must have a high school diploma or its equivalent and a satisfactory special health report.

CURRENT FACULTY, STUDENTS, GRADUATES

Eight registered technicians at St. John's devote one-quarter time to teaching clinical aspects of radiology; the full-time director of the program splits his time evenly between administration and teaching responsibilities. Resident radiologists and physicians at St. John's also assist in training. The enrollment (approximately 75 percent are women) is limited by the AMA to seven students per year making a stable total of 14 students in this two-year program. Because of Joplin's geographical proximity to three states other than Missouri, almost one-quarter of the students in the program are out-of-state. Roughly half are employed upon graduation and certification in the geographic area close to Joplin. Job offers, according to the faculty, are numerous; and all graduates have been employed in their field of training. Students usually elect to work in hospitals rather than industry because they sense the former affords a greater contact with the public.

PROGRAM PROJECTIONS

Recent rulings by the AMA concerning supervised student-taken X-rays and the job market expansion at the instructional and supervisory levels indicate the feasibility of developing a B.S. degree at MSSC in Radiologic Technology. Facilities for the current program are excellent, but a second affiliate hospital willing to absorb the program costs as St. John's has done will be needed if additional students are to be enrolled. The faculty contend that the jobs are available for an expanded enrollment. One or two registered technicians are expected to be added to the St. John's staff this year (1978) due to the addition of computerized auxiliary tomography equipment. Like other courses of study that require licensing, radiologic technology enjoys a prestigious image at MSSC as a quality program.

COURSE DESCRIPTION

5207-101 Introduction to Radiology - An overview of the organization, function, supervision, and financing of a radiology department including the relationship with other hospital departments. The course includes a history of X-ray, ethical principles, and legal aspects of technology and elementary radiation protection. (3 s.h.)

5207-132 Principles of Radiographic Exposure - The fundamental principles of technique and technique conversion with particular emphasis on the factors that directly and indirectly affect radiographic exposure. Emphasis on dark room chemistry and technique are also included in this course. (3 s.h.)

5207-170 Radiologic Physics I - The physics of radiology. The physical principles of X-ray production, radiographic exposure, film density and construction, fluorescent screen, etc. Basic equipment maintenance is included. (3 s.h.)

5207-180 Practicum in Radiology I - Designed to develop the knowledge and skills necessary to produce X-ray films with speed and accuracy. (5 s.h.)

5207-271 Radiological Physics II - Physical principles of radiation therapy and isotopes. Includes theory, application, and basic equipment maintenance. (3 s.h.)

5207-290 Practicum in Radiology II - Intensive clinical experience in regular working conditions under the close supervision of a radiologist and an experienced radiation therapy technologist. (5 s.h.)

5207-299 Advanced Radiology - A comprehensive review of the field of Radiologic Technology including innovation, trends, and anticipated advancements in the field. (3 s.h.)

INSTITUTION: OAK RIDGE ASSOCIATED UNIVERSITIES (ORAU)

PROGRAM: Radiation Emergency Assistance Center/Training Site

DEPARTMENT: Medical and Health Sciences Division

DEGREE: Certificate of Attendance

CONTACT: Mr. Roger Cloutier
Oak Ridge Associated Universities
P.O. Box 117
Oak Ridge, Tennessee 37830
(615) 483-6352 (ext:263)

PROGRAM DESCRIPTION:

PROGRAM STRUCTURE

In 1946, when Oak Ridge Associated Universities got its start, the region in which it is located was largely agricultural, as was the largest portion of the south. ORAU then determined its role to be one of scientific leadership and so it served as a diffusion source of scientific and technical knowledge. During the past three decades of its existence, southern universities have made substantial gains and now have rich and varied scientific intellectual resources and facilities on their campuses. Responding to this greater degree of sophistication ORAU's purpose evolved as one of bringing the resources of these member institutions to bear on the serious scientific and technical problems facing society. Today, Oak Ridge Associated University is a consortium of forty-three southern universities (including the University of Puerto Rico).

The ORAU Council, which consists of a representative from each of the member universities and colleges, determined in 1975 that three themes should underlie ORAU activities: energy, health, and environment. That same council reviews all of the ORAU programs.

The Institute for Energy Analysis was formed in 1974 to provide broad, critical, informed analyses of energy problems, and to assess alternatives as a basis for formulation of rational energy policies. The Museum Division conducts national education and information programs to improve the public understanding of energy and its environmental effects. The Energy Education Office operates traveling high school programs called "Energy Today and Tomorrow" and "This Atomic World". Public information workshops are offered regularly.

The University Programs Office, Special Training Division, and Manpower Development Division are consolidated under a centralized administration known as the Manpower Education, Research, and Training Division (MERT). The division is chiefly concerned with the skilled and professional manpower needed to deal with the nation's energy and related health and environmental problems. A discussion of MERT is included in this report.

The Radiation Emergency Assistance Center/Training Site (REAC/TS) comes under the Medical and Health Services Division and is housed in the new emergency wing of the Oak Ridge Hospital. REAC/TS facilities include a special room for decontaminating radiation accident victims, a surgical suite for operating on persons with wounds contaminated by radiation, and additional space and resources for radioassay, records, and emergency medical training. REAC/TS treats persons who are accidentally exposed to radiation, provides consultant services, and offers short, intensive training courses in detection, monitoring, and biological effects of radiation; descriptions of which follow.

REAC/TS conducts a major program for the Department of Energy on epidemiologic aspects of human radiation and toxic metal exposures; it has, in addition, computerized data banks on accidental and medical exposures. REAC/TS is also the center for the distribution and assessment of DTPA, a drug used to enhance the excretion of radioactive materials accidentally taken into the body. ORAU's Medical and Health Sciences Division is co-sponsored by the Divisions of Biomedical and Environmental Research and Safety, Standards, and Compliance of the Department of Energy (formerly ERDA).

PROGRAM REQUIREMENTS

In order to participate in one of the REAC/TS courses one must register two weeks prior to the beginning of classes. There is no tuition fee per se, however fifty dollars for incidental expenses during the course is payable on the first day in attendance.

The course dealing with medical planning and care in radiation accidents is open to a maximum of thirty-five physicians who provide medical services to the nuclear industry, and to city, county, and state health officers who may be called on to provide first aid or medical care in the event of a radiation accident.

The second of the REAC/TS courses is Health Physics in Radiation Accidents. It is designed for health physicists who may be called upon to respond to accidents involving radioactive materials and personal injury. A maximum of twenty-four people may enroll each time it is offered.

A two day course has been designed for emergency room surgeons and nurses who may be called on to administer the initial treatment for radiation accident victims. Twenty-four is the maximum enrollment.

CURRENT FACULTY, STUDENTS, GRADUATES

REAC/TS has at its disposal a scientific faculty of nineteen professional, four of whom are directly assigned to REAC/TS. Commonly, guest speakers with a particular area of expertise will assist in programs.

Often times, students will have a sponsor who pays his/her fees. Sponsoring organizations in the past have been Nuclear Power Utilities, Health Departments, or state or federal agencies. Courses are normally filled to capacity.

Approximately three hundred and fifty individuals have taken advantage of REAC/TS courses in the past. The courses are acceptable for credit in Category 1 for the Physician's Recognition Award by the American Medical Association. Application for credit has been filed with the American College of Emergency Physicians. In addition, these courses meet requirements of the Nuclear Regulatory Commission for training emergency personnel.

PROGRAM PROJECTIONS

Because ORAU is designed to be responsive to the needs of a changing environment, it will add and alter its course offerings in response to these changes. The short course format allows flexibility in scheduling new materials in subsequent courses of like or similar kind. REAC/TS anticipates being in even greater demand as the nuclear technology becomes increasingly sophisticated and widespread.

COURSE DESCRIPTION

Medical Planning and Care in Radiation Accidents - Fundamentals of radiation and radiobiology, radiation detection and measurement, care of radioactively contaminated injuries, evaluation and treatment of internal radioactive contamination, acute radiation syndromes. Equipment and facilities used in evaluation and treatment of radiation of radiation injuries are demonstrated. Offered twice during the academic year (AY) 1977-78. One week in duration.

Health Physics in Radiation Accidents - Radiation physics review, radiation detection and measurement, instrumentation, radiation biology, dosimetry, protective clothing and equipment, emergency procedures. Simulated accident drill. Offered once during AY 1977-78. One week in duration.

Handling of Radiation Accidents by Emergency Personnel - Emphasis on practical aspects of handling contaminated victims, fundamentals of radiaiton, detection, measurement and prevention of contamination. Simulated accident drill, exercises and demonstrations. Offered three times during AY 1977-78. Two days in duration.

INSTITUTION: OAK RIDGE ASSOCIATED UNIVERSITIES (ORAU)

PROGRAM: Special Training

DEPARTMENT: Manpower Education and Research Training Division (MERT)

DEGREE: Certificate of Participation

CONTACT: Mr. Roger Cloutier
Oak Ridge Associated Universities
P.O. Box 117
Oak Ridge, Tennessee 37830
(615) 483-6352 (ext: 263)

PROGRAM DESCRIPTION:

PROGRAM STRUCTURE

Oak Ridge Associated Universities got its start in 1946, at a time when the south was largely agricultural. Then ORAU determined the appropriate role for it to assume was one of scientific leadership, so it began as a center for the diffusion of scientific and technical knowledge. Since then, southern universities have made substantial gains and now have rich and varied scientific facilities and intellectual resources. Responding to this high level of sophistication, ORAU's purpose evolved to be the application of the resources of member institutions to the critical scientific and technical problems facing society today.

The ORAU Council is composed of one representative from each of the forty-three southern universities (includes university of Puerto Rico) which comprise this consortium. In 1975 a meeting of the Council determined that three themes would lay the foundation for ORAU activities: energy, health and environment. This body sits in review of all programs offered by ORAU.

In 1974 the Institute for Energy Analysis was formed to provide broad, critical, informed analyses of energy problems, and too, to assess alternative solutions as the bases for rational energy policy formulation. The Museum Division is based in the three year old American Museum of Atomic Energy and it conducts national education and information programs to improve the public understanding of energy and its environmental effects. The Energy Education office operates traveling high school programs called "Energy Today and Tomorrow" and "This Atomic World". Public information workshops are conducted out of this office regularly.

The Medical and Health Sciences Division's purpose is to conduct research in biomedical and environmental medicine to help meet the need for understanding and effectively treating occupational health hazards of new energy technology. Immunobiology, biochemistry, radio pharmaceuticals, human radiation biology, and epidemiology are the main research areas. The Radiation Emergency Assistance Center/Training Site (REAC/TS) is housed in a specially equipped emergency wing of the Oak Ridge Hospital. Its function is to treat persons who are accidentally exposed to radiation, to provide consultant services, and to offer short, intensive training courses in detection, monitoring, and biological effects of radiation (description appears in this summary).

The Manpower Education, Research and Training Division (MERT) is a recent consolidation of the University Programs Office, Special Training Division, and the Manpower Development Division. Its main concern is with the skilled and professional manpower needed to effectively deal with the nation's energy and related health and environmental problems.

University Programs offers faculty members and students of member institutions the opportunity to conduct research and development using the facilities at the Oak Ridge National Laboratory (ORNL). More than thirteen hundred faculty members have taken advantage of summer research appointments since this program got under way in 1946. Laboratory Graduate Participation, established in 1948, has allowed more than three hundred master's and doctoral candidates in the sciences, engineering, and mathematics to do research for theses or dissertations. Ten-week summer appointments are open to seniors in college who are majoring in engineering, mathematics, and the natural sciences. Over thirteen hundred students have participated in research projects through this program. In contrast to bringing students and faculty into the laboratory, the Traveling Lecture Program takes professional researchers to the classroom to lecture and participate in colloquia and conferences.

Training and research are the primary activities of the Manpower Development Division. Training and Technology (TAT) began in 1966, and has since prepared nearly four thousand unemployed or underemployed individuals for the industrial workforce, with a job placement rate of 90 percent for graduates. Special Training programs at ORAU are designed to reflect U.S. training needs, particularly those related to energy. These programs were organized in 1948 to provide professional training for scientists and engineers planning to use radiation and radioactive materials in their research. Since that time, changes have been made in keeping with national priorities. Faculty Institutes bring selected faculty of small colleges and universities back to the classroom for summer institutes imparting information on energy research and development, conservation, and environmental problems. Recent topics have dealt with energy sources for the future, biological applications of radiation, nuclear power safety, energy production and the social sciences, and radiotracer techniques in ecology.

Special Department of Energy (DOE) Training courses are provided for scientists and engineers employed by the DOE and its contractors.

Course topics include present energy sources such as fossil, hydro, and nuclear, and prospective sources such as solar, geothermal and thermonuclear. This program has an increasingly important role as the nation strives for energy independence. Special Training conducts a ten-week Health Physics Training course, which is sponsored by the Nuclear Regulatory Commission. Responding to the need for more physicians trained in nuclear medicine, this program offers special training to practicing physicians emphasizing the fundamentals of nuclear medicine. The Resident Graduate Program makes graduate-level courses from the University of Tennessee available to DOE employees and its contractors.

PROGRAM REQUIREMENTS

Health Physics and Radiation Protection is a ten-week, four hundred hour course, which is open to qualified applicants from governmental agencies, educational institutions, and the private nuclear industry. Applicants should have a bachelor's degree in science or engineering, or equivalent training. The admissions committee, representing ORAU, the Nuclear Regulatory Commission and the DOE, will permit a maximum enrollment of twenty-four. A tuition of $3,60C dollars pays for books, materials and field trips.

Applications for participation in the Summer Faculty Institute must be accompanied by a letter of recommendation and will be ranked according to the applicant's qualifications and need for the program as judged by a committee of ORAU and DOE representatives.

A five-week Applied Health Physics course is open to qualified professionals from the private nuclear industry, governmental agencies, and educational institutions. Prerequisites for attending this program are a bachelor's degree or some health physics experience.

CURRENT FACULTY, STUDENTS, GRADUATES

There are nineteen persons who make up the scientific faculty at ORAU, three of whom are fully involved with the Special Training Division. Two of the Special Training designates are health physicists.

Students come from varied backgrounds. Commonly they are from educational institutions, from governmental agencies, and from the private nuclear industry. Course sizes are limited due to the laboratory orientation of most offerings. Certificates of participation are awarded upon completion of each course.

PROGRAM PROJECTIONS

This description is in no way complete with regard to all of ORAU's activities, but is a sampling. Programs will continue to be responsive to technological advances and to the level of skill requirements for utilization of such technologies.

COURSE DESCRIPCION (SELECTED)

Health Physics and Radiation Protection - A special four-hundred hour course emphasizing the fundamentals of health physics, the problems and practices in providing radiation protection, the mechanism of radiation damage, and methods and procedures for evaluating radiation hazards. Considered to be excellent preparation for the American Board of Health Physics Examination. Maximum enrollment: twenty-four. Duration: ten weeks.

Radiation Techniques for Quality Assurance in Energy Production - Orientation to a variety of radiation techniques that are being used for the analysis of fuels, process materials and wastes associated with the production of energy. Techniques include x-ray flourescence, neutron activation and high resolution gamma-ray spectrometry. Maximum enrollment: sixteen. Duration: three weeks.

Nuclear Power Safety - Introduction to safety measures taken in construction and operation of nuclear power plants. Emphasis on evaluation of Environmental Impact Statements and Safety Analysis Reports. Review of recent reactor safety studies of ERDA, NRC, APS, and others. Maximum enrollment: twenty four. Duration: one week.

Energy Production and the Environment - Introduction to forms of energy production now in use and under consideration. Measurement of impact of energy production on the environment. Modeling as a tool for evaluation of alternate environmental costs of each energy source. Fossil fuels, nuclear, geothermal, solar, solid wastes, hydrogen are considered. Energy transport. Environmental planning for efficient use of energy. Alternatives to energy growth. Maximum enrollment: sixteen. Duration: two weeks.

Biological and Ecological Applications of Radiation - Demonstration of uses of radiotracer techniques in biological and ecological systems. Radiation physics, gamma-ray spectrometry, liquid scintillation counting, activation analysis, x-ray flourescence analysis. Applications topics include static and dynamic studies in bioecosystems. Emphasis on radiation safety. Maximum enrollment: sixteen. Duration: three weeks.

Energy Options for the Future - Overview of the nation's current energy problems and the various options for immediate and longer range solutions. Currently available energy sources, such as fossil, hydro, and nuclear are considered, as well as prospective sources such as solar, geothermal, thermonuclear, and breeder reactors. Maximum enrollment: twenty-four. Duration two weeks.

Energy Conservation: Theory and Practice - Potential benefits of energy conservation in the home, transportation, agriculture, and industry. Theory and practice of energy conservation are stressed. Simple techniques for measuring energy consumption and methods for evaluating the effectiveness of energy conservation practices. Examination of the rate of State and Federal legislation and public education on energy conservation. Maximum enrollment: twenty-four. Duration: two weeks.

INSTITUTION: OKLAHOMA STATE UNIVERSITY

PROGRAM: Radiation and Nuclear Engineering Technology

DEPARTMENT: Radiation and Nuclear Engineering Technology

DEGREE: Associate Degree (A.D.) and Bachelor of Science (B.S.) in Radiation and Nuclear Technology

CONTACT: Dr. Perry R. McNeil
Associate Professor and Head
Radiation and Nuclear Technology
Oklahoma State University
Stillwater, Oklahoma 74074
(405) 624-5716

PROGRAM DESCRIPTION:

PROGRAM STRUCTURE

Radiation and nuclear engineering technology education at Oklahoma State University is currently composed of two degree programs: the Associate Degree (A.D.) program and the Bachelor of Science (B.S.) degree program.

The radiation and nuclear Associate Degree program has been an integral part of engineering technology education at OSU since 1964. Radiation and nuclear is one of eight two-year technical Associate Degree program offerings. Traditionally, program emphasis has been oriented towards the practical application of engineering technology. Although graduates of this two year program are qualified technicians, 75% pursue further education usually through the OSU engineering technology program. Continuation is strongly encouraged by the faculty.

In 1969 Oklahoma State University expanded the five year old radiation and nuclear engineering technology program to include the offering of a Bachelor of Science degree. The two year program, designed to train technicians, was augmented with the addition of advanced radiation and nuclear curriculum to educate engineering technologists. Radiation and nuclear is one of ten bachelor of science engineering technology programs. The baccalaureate degree technologist receives intensive training in his technical specialty with strong emphasis in mathematics and the technical sciences. With a background in practical applications, the technologist is able to implement the plans and designs as conceived by the engineer.

Historically, those students choosing a career path at the A.D. level have found employment in occupations which include: nuclear medicine technician; environmental specialist; radiation inspector; health physics technician or monitor; and, nuclear materials technician.

The majority of these technicians found employment opportunities in public health, hospital and university laboratories, nuclear power facilities and a wide variety of industries which utilize X-ray equipment and nuclear instruments.

Although baccalaureate graduates of the OSU radiation and nuclear engineering technology program find easy access to challenging occupations, approximately 25% pursue advanced degrees. Those students electing to enter the job market, obtain employment in occupations which include: energy efficiency technologist; well logger; environmental specialist; radiation inspector; radiological health specialist; and, nuclear technologist.

Students in the radiation and nuclear programs receive extensive laboratory experience which provides practical applications of the classroom training. At the present time, this is the only baccalaureate program of its kind to be accredited by the Engineers Council for Professional Development.

PROGRAM REQUIREMENTS

Admission to OSU is determined upon resident status. Residents of the state who have graduated from an accredited high school and meet testing and academic requirements may be admitted to the program. Nonresidents and transfer students are eligible for admission pursuant to requirements specified by the admission committee.

Requirements for completion of the Associate Degree (A.D.) include 39 credit hours of English, science, mathematics, and social sciences. Technician speciality courses include 22 credit hours of radiation and nuclear technology. There are no general or controlled electives available to the student pursuing the Associate Degree.

At the present time the matriculated baccalaureate student must complete the following requirements in order to be eligible for the Bachelor of Science degree: 47 credit hours in English, science, and humanities; 15 credit hours in mathematics; 22 credit hours in technician speciality courses; 27 credit hours in technologist speciality courses; and, seven credit hours in upper division related specialty courses. In addition, the student must complete four credit hours of general electives in any field and six credit hours in upper division controlled electives from: engineering, technology, mathematics, statistics, computer science, business law, accounting, management, marketing, botany, finance, zoology, economics, geology, physics, chemistry, astronomy, agriculture and/or meteorology. The students in both programs, must maintain at least a 2.00 overall grade point average.

Although the majority of students meet tuition obligations through individual means, there is one $500 scholarship available. A few are employed by the university and/or participate in work-study programs. At present, there is no formal internship program or applied study term, but students are encouraged to find summer employment in fields compatible with their academic studies. Approximately 15% of the students find summer employment (i.e., at the TVA nuclear power plant or hospitals) and subsequently they may prepare a paper for which they are awarded two credit hours.

CURRENT FACULTY, STUDENTS, GRADUATES

The current full-time faculty includes: 2.25 teachers and one full-time equivalent graduate assistant; research staff equal .50 faculty and one full-time equivalent lab technician; and, administration requires .25 faculty. All faculty are cost-centered, and the current total reflects a decrease of one full-time teacher since 1973.

The majority of the radiation and nuclear technology students enter the programs directly from high school. Usually the programs do not attract returning career change students. The total current enrollment includes 51 full-time students of which 72% are male and 28% are female. Approximately 13 students may be identified as utilizing the program in a terminal sense upon completion of the Associate Degree. Per annum graduates at both levels have averaged 8 to 10 over the last three years.

PROGRAM PROJECTIONS

In the fall of 1978, the Associate Degree program will be terminated, and certain required course modifications will be instituted in order to expand the baccalaureate program. Changes will include at the lower division level: three credit hours in additional English; four credit hours decrease in technician specialty courses; and, three credit hours additional related specialty courses. At the upper division level changes will include: three credit hours decrease in communications; six credit hours in additional technologist specialty courses; and, five credit hours in additional related specialty courses.

The faculty is projected to increase by one person with at least a Master of Science and industrial experience in the radiation and/or nuclear areas. This faculty increase is projected to occur within the next two years.

The student enrollment is projected to increase at approximately 20% per annum in response to the expansion plans for the baccalaureate program.

COURSE DESCRIPTION

RNT 1114 History and Fundamentals of Radiation - Introduction of the basic concepts of particulate and electromagnetic radiation. The subject of radiation is presented according to historical development. (Lab.3 s.h.)

RNT 1233 Public Health Aspects of Radiation - Acquaints the student with public health organization and administration and provides an introduction to basic health radiation protection practices.

RNT 2214 Radiological Health I - Personnel radiation exposure, radiation protection guides, critical considerations and problems, RNT 2214 (Cont'd) - radiation exposure guides and systems for calculation, nuclear industry practices, problems and features of Kilocurie radiation sources. (Lab. 3 s.h.)

RNT 2315 Radiation Measurement I - Measurement of radio-activity and calibration of GM gas low proportional and scintillation counters; dosimetry of alpha, beta, gamma, X-ray neutron sources together with electronic, physical and chemical systems of dosimetry. (Lab. 6 s.h.)

RNT 2404 Environmental Radiation Fundamentals - Radioactive waste disposal techniques and practices, environmental radiation surveillance, radiation dose calculations, radionuclide uptake, low level concentration of radionuclides in food, water and soil. (Lab. 3 s.h.)

RNT 2522 Special Problems - Comprehensive study of the radiological health field and problems, guest lectures, student group presentation of selected problems, review of modern physics literature and familiarization with radiological health literature and reference materials. (Lab. 3 s.h.)

RNT 2624 X-Ray Radiation - Introduction to the basic principles of X-ray production, X-ray spectrum, X-ray machines, medical and industrial applications and practice, shielding and filter systems, design of X-ray facilities, calibration and dosimetry of X-ray. (Lab. 3 s.h.)

RNT 3125 Radiation Biology - Principles of interaction of radiations with living tissues, introduction to target theory, LET concept, LD50 relationships and tissue damage concepts. (Lab. 3 s.h.)

RNT 3233 Radiological Safety - Ionizing radiation problems with stress on detection and measurement, shielding and exposure-limiting, radiation health aspects, storage, handling and disposal. (Lab. 3 s.h.)

RNT 4003 Nuclear Power - Treatment of conditions necessary for sustained nuclear chain reaction. Reactor kinetics and shielding and measurements of nuclear properties of fuels and moderators. (Lab. 3 s.h.)

RNT 4324 Radiation Measurements II - A continuation of 2315.

RNT 4413 Health Physics Practices - Introduction to established practices and techniques used in personnel monitoring, area monitoring, radiation surveys, hazards evaluation, storage operations, radioactive waste disposal and other health physics activities. (Lab. 2 s.h.)

INSTITUTION: RENSSELAER POLYTECHNIC INSTITUTE

PROGRAM: Nuclear Engineering

DEPARTMENT: Nuclear Engineering

DEGREE: Bachelor of Science (B.S.); Master of Science (M.S.); Master of Engineering (M.E.); Doctor of Philosophy in Nuclear Engineering (Ph.D.)

CONTACT: Dr. J.C. Corelli
Nuclear Engineering Department
Rensselaer Polytechnic Institute
Troy, New York 12181
(518) 270-6403

PROGRAM DESCRIPTION:

PROGRAM STRUCTURE

Initiated in 1960, the Nuclear Engineering Department offers programs of instruction for both undergraduates and graduate students. The undergraduate program's principal aim is on the energy product aspects of nuclear reactor technology. Areas of concentration are available in: Reactor Physics; Reactor Engineering; Applied Physics; and Health Physics. The Health Physics Concentration is intended for Professional Program students who wish to develop expertise in tha radiation safety aspects of nuclear power plant operations and the associated nuclear fuel cycle. Undergraduates can select eight electives from this concentration which are directly related to radiation control. The undergraduate program is intended to prepare students for either industrial employment or graduate study. The program is monitored by an industrial advisory council composed of representatives of various companies in the energy field.

The graduate program in Nuclear Engineering is mainly related to both fundamental research and industrial applications, and is mostly concerned with electric power production from nuclear energy. Other areas of emphasis are medical and other uses of radiation and radioactive materials, reactor thermalhydraulics, reliability and safety, fusion materials technology, radiation wastes, and applied physics. In the graduate program, students select courses covering specialized material in any program area and work with a member of the faculty or research staff who has corresponding interests. The student's research topic is selected in consultation with the faculty or research staff member who works in the student's area of interest. The individual's needs and career objectives are met through core courses, course work in a particular area of concentration, and associated research programs.

The Nuclear Engineering Department contains a large number of various facilities: a 100-million electron-volt linear accelerator; extensive mass and radiation spectrometry facilities; a large critical facility for operational training and safety studies; two-phase flow loops; probes to determine radiation damage in biological materials, fusion reactor materials, and semiconductors; computer terminals linked to large remote computers; an in-house developed interactive graphics computer system; a high-current, low voltage electron accelerator for low voltage electron accelator for low-energy radiation damage effects; and a Van de Graaf accelerator subcritical reactor assembly.

PROGRAM REQUIREMENTS

In order to enter as candidates for the Bachelor of Science degree, applicants are evaluated by Rensselaer's Committee on Admissions. This Committee pays particular attention in its evaluation to:
(1) Academic performanae throughout secondary school;
(2) results of the College Entrance Examination Board Scholastic Aptitude Tests and Achievement Tests, in English composition, physics or chemistry and Mathematics I or II;
(3) the recommendation from the applicant's school; and
(4) character and extracurricular achievements.
Prospective applicants to the graduate program must have a Bachelor of Science degree in Nuclear Engineering or any other engineering branch. Also accepted are students possessing a Bachelor of Science degree in physics or mathematics.

Undergraduates may follow either a program leading to the Bachelor of Science degree or be admitted to the professional program leading to the Master of Engineering degree as well as the Bachelor of Science degree. For example, a student can elect a concentration in radiological health (5 yr. program) after earning the B.S. degree and supplement the program with electives to develop a minor in health physics. Two electives can be taken as a senior in radiation health.

The engineering baccalaureate program requires completion of a total of 133 semester credtis. Twenty-four credit hours of humanities and social sciences electives are required. One course in computing and a sequence of other mathematics courses, at least through advanced calculus, are also required to earn the bachelor's degree. Nuclear Engineering courses required include: 30.282 Introductory Nucleonics; 38.471 Radiological Engineering; 38.401 Elements of Reactor Engineering; 38.412 Nuclear Reactor Analysis I; and 38.402 Nuclear Energy Conversion. Three additional Nuclear Engineering courses are generally elected by many B.S. students.

The first year of the Master of Engineering professional program requires course work that is more heavily oriented toward advanced Nuclear Engineering courses, Mathematics courses, and laboratory courses. Seniors with advanced placement may supplement their course work with electives in an area of concentration. The second year normally consists of eighteen course credits and six credits of 38.698 Master's Project of 38.699 Master's Master's Thesis. One credit of 38.910 Engineering Seminar is required. A minimum total of thirty credits which include ten credits of design-oriented courses and ten hours in advanced mathematics and engineering science are required. Only students with B.S. degrees from institutions accredited by the Engineers' Council for Professional Development (ECPD) are admitted to the M.Eng. program. The B.S. program is also accredited by the ECPD.

The Master of Science degree program is arranged by consultation with a faculty advisor and the formal minimum requirement is 24 credits of course work, one credit hour of 38.910 (Seminar), and 6 credits of the master's thesis. M.S. students may take 5 to 6 courses from the Health Phsycis Concentration and prepare 6 credits of research in a radiation effects or radiological health project to develop a program of study in radiation protection.

A thesis advisor assists students in preparing advanced study and research in the doctoral programs. Ususally 45 to 60 course credits beyond the B.S. degree are required in addition to the residence and thesis requirements. Each Ph.D. candidate is required to submit a draft of a technical paper to be published in a referred journal.

Financial aid available includes two fellowships from the Department of Energy (formerly ERDA), four industry fellowships, four teaching assistantships, and 20 research assistantships. Program officials would like to develop a stronger radiation protection program but currently lack a U.S. Environmental Protection Agency fellowship to enable it to be started.

CURRENT FACULTY, STUDENTS, GRADUATES

Eleven full-time teaching faculty present the Nuclear Engineering Department's curriculum to students. All full-time faculty members are involved in conducting research. They are partially (50%) supported by research funding. Current areas of advanced study and research which impact radiation protection topics include: radiation effects in materials; reactor safety; radioactive waste management; and environmental measurement. The department's faculty are also conducting a project on the effects of ionizing and non-ionizing radiation on biological systems.

A total of 115 full-time students are enrolled in the baccalaureate program (7 females). Six undergraduates have elected health physics courses as elective concentrations, and it is estimated that three to four students have elected the environmental surveillance concentration of courses. At the M.S. level, there is currently a total of 62 students enrolled. Of the total, there are 50 full-time (3 female) and 12 part-time students enrolled. Seventeen full-time students are enrolled in the doctoral program

Department officials estimate that an annual three-year average of 30 B.S. degrees, 18 M.E. and M.S., and 5 Ph.D.s are granted. Enrollment appears to have increased significantly over the past few years.

Forty percent of the M.S. graduates contine on to earn doctorates. Many stay on at the Rensselaer Polytechnic Institute, but others (in the past) have contined on to programs offered by such schools as the Massachusetts Institute of Technology, the University of Virginia, the University of Michigan, and Cornell University.

Virtually all graduates obtain employment directly in their field, and a predominate number (40%) obtain governmental positions in agencies such as the U.S. Nuclear Regulatory Commission in preparing environmental impact assessments of nuclear power plants. Others find radiological health positions at nuclear power facilities and national laboratories. Some graduates secure jobs in nuclear power plant operations, and others find positions in nuclear medicine or in radiology departments in hospitals.

PROGRAM PROJECTIONS

Department officials project a greater need for graduates trained in radioactive waste management in future years. One new faculty member is to be recruited to teach nuclear waste management. By 1978, the department hopes to recruit a Ph.D. with training in radiation waste management, as this is an area in which the department is currently lacking in expertise. An additional two graduate fellowships are needed to develop a strong area of concentration in the Nuclear Engineering Department in radiation waste management. Enrollment in both the undergraduate and graduate programs is expected to continue increasing.

COURSE DESCRIPTION

(the following is a partial listing of courses)

38.406 Nuclear Fuel Management - Sources of nuclear fuel. Mining, milling and purification. Principles of isotope enrichment; specific methods with emphasis on gaseous diffusion. Other important topics. (4 s.h.)

38.628 Interaction of Radiation with Biomaterials - Ionizing and nonionizing energy transfer processes to biomaterial such as live mammalian and bacterial cells. (3 s.h.)

38.629 Health Physics and Medical Aspects of Radiation - Use of radiation in nuclear medicine, effects of ionizing and non-ionizing radiation in biological systems. Radiation and environment interactions. (3 s.h.)

38.632 Safety Controls for Nuclear Operations - Emphasis is on nuclear power plants but other power systems are included. Analysis and review of quality assurance of systems and quality control, atmospheric diffusion of plant effluents, and others. (3 s.h.)

38.635 Radiation Shielding - A course concerned with the design and analysis of radiation shielding. The emphasis is on shielding design and analysis in the nuclear power industry. (3 s.h.)

Chemistry:

72.471 Nuclear Chemistry - Properties and models of atomic nuclei, radioactive decay processes, laws of growth and decay of radionuclides, properties of nuclear radiation, interactions of nuclear radiation with matter, nuclear instrumentation, radiation protection, nuclear reactions, methods of radiochemistry. (3 s.h.)

72.472 Radiochemistry - Radioactivity measurements; determination of half-life and radiation characteristics of radionuclides; study of genetic relationships, radiochemical separation methods; autoradiography; characteristics of radiation detectors including gaseous, solid and liquid scintillation and solid state types; nuclear spectrometry by both single and multichannel pulse-height analysis; isotope dilution and activation analysis. (3 s.h.)

INSTITUTION: RUTGERS - THE STATE UNIVERSITY OF NEW JERSEY

PROGRAM: Radiation Science

DEPARTMENT: Radiation Science

DEGREE: Master of Science (M.S.)
Doctor of Philosophy (Ph.D.)

CONTACT: Dr. Francis J. Haughey
Director of Graduate Programs in Radiation Science
Room 116, Doolittle Bldg.
Busch Campus, Rutgers University
New Brunswick, New Jersey 08903
(201) 932-2582

PROGRAM DESCRIPTION:

PROGRAM STRUCTURE

The graduate program of Rutgers University in Radiation Science is one of the oldest in the nation. It was initiated in 1962 and between 1965 and 1975, had granted more Masters degrees (94) than any other institution of higher education in the United States. Between 1962 and 1977, 135 full-time and 52 part-time students have attended the graduate program in Radiation Science at Rutgers and a total of 106 M.S. degrees and 18 Ph.D. degrees have been earned. Taking into consideration the time constraint for experience requirements, twelve of the 84 (14 percent) of Rutgers graduates have become certified through 1971 by the American Board of Health Physics, the American Board of Radiology, and others.

The graduate program in Radiation Science at Rutgers emphasizes a broad basic training in the disciplines supporting Radiation Science. Four sequences running through two terms have been developed and include: (1) nuclear physics, with radiation chemistry and dosimetry, (2) radiation detection instruments and electronics, (3) radiation biology, and special topics including waste disposal, toxicology, medical radiation exposures, etc., and (4) environmental sciences or medical physics. Graduates are qualified to serve as health physicists, radiological health specialists, and other related positions in medical physics, health physics, and environmental organizations.

Facilities available to Radiation Science graduate students include a fully equipped laboratory with the latest in instrumentation. Research funding is currently available from the Nuclear Regulatory Commission, the National Cancer Institute, and the

Department of Energy. Traditional sources of funding in the past has been the U.S. Department of Health, Education and Welfare, the U.S. Environmental Protection Agency, and the Atomic Energy Commission.

Ten Radiation Science seminars are conducted in the fall and spring terms of each year by experts in the field for the benefit of the program's faculty and students. The curriculum has been structured to prepare students to meet the professional requirements of the certification program of the American Board of Health Physics, the American Board of Radiology, and others.

PROGRAM REQUIREMENTS

For admission to the graduate program, qualified candidates with undergraduate degrees in chemistry, physics, biology, engineering, pharmacy, or other acceptable fields, and who meet the Graduate School's admission requirements, will be considered. The Graduate School requires a B or better average in previous academic work, letters of recommendation, and Graduate Record Examination scores.

The Master of Science degree requires a total of 30 credit hours of graduate study. Some students may elect to prepare a master's thesis of six credits and take 24 hours of course work to complete the degree requirements. Seventeen credits of a Radiation Science core must be taken in biology, chemistry, physics, and instrumentation. Some students may be required to take non-graduate credit preparation courses prior to taking the core curriculum.

Three professional options are offered: radiation safety; health physics; and medical physics. Radiation Safety students can elect specialty courses in toxicology, industrial hygiene or epidemiology. Health Physics students may elect specialty courses in Air Sampling, Meteorology or other special topics. Students taking the third option, may take specialty courses in anatomy; computer sciences, and other special topic areas. An internship is required for students in Radiation Science and three to ten credits of electives and seminars may be taken in biology, chemistry, physics, mathematics, statistics, engineering, meteorology, and others. The Radiation Science research programs depends on student preparation and research plans.

The Radiation Science Internship Program is one of Radiation Science's basic requirements of all students. Radiation Safety and Health Physics students usually have summer internships available to them at the Brookhaven National Laboratory, Long Island, New York. There are also other internships available to Radiation Safety and Health Physics students at E. R. Squibb and Medi-Physics Inc. The internship program for Radiation Safety students is oriented toward health physics and environmental protection. Medical Physics students participate in internships sponsored by St. Barnabus and St. Peters Hospitals, New Jersey, and their orientation is basically clinical.

Formerly, Radiation Science students were able to obtain Environmental Protection Agency and Atomic Energy Commission Fellowships but none are currently available. The Radiation Program has applied for a U.S. Energy Research and Development (Department of Energy) training grant.

CURRENT FACULTY, STUDENTS, GRADUATES

The Radiation Science Program has a total graduate faculty of ten full-time and adjunct professors (including one associate member). Some of the professors are also members of other departments. Instructors devote half time to teaching and half to research. Two of the adjunct faculty are members of other state medical centers staff. A total of 45 full-and part-time students are enrolled in the graduate Radiation Science Program. Most of the students are part time (37) and five are female. One-half of the eight full-time students are female. The principal reason for the predominance of part-time students is the fact that little financial aid is available to help support students. Most have jobs in their field at nearby research laboratories or hospitals. An average of 12 students annually receive the Master of Science degree and three receive Ph.D.s.

Some graduates continue their education at medical schools and other doctoral programs. Officials are unaware of any graduates still seeking employment and stated that the program would double its present enrollment and still place them into jobs because of the reputation and momentum built by the Rutgers program. It is estimated by program officials that three jobs currently exist for each graduate and lists of students are sent to the Health Physics Society's Placement Service for assistance in finding employment. Most students secure jobs with governmental or medical institutions (60 percent) and the rest find employment (30 percent) with private firms.

PROGRAM PROJECTIONS

The Radiation Science Program intends to develop another specialty within the Master of Science degree requirements in the area of occupational health and safety. The University's Radiation Safety Department is hiring an industrial hygienist and this person will be available to teach courses for Radiation Science students. The Radiation Science Department also intends to expand its program with a greater emphasis on biophysics and thereby develop further toward basic sciences for post M.S. students.

Within the next five years, three additional faculty members are expected to be recruited to help teach the Radiation Science curriculum. The three include: one Radiation-Physicist with a specialty in instrumentation, one Radiation-Biologist with a zoology emphasis and genetics; and a Bio-physicist with a general background.

Program officials foresee a continued interest in the environmental radiation field especially in the area of nuclear power and also nuclear medicine and medical physics.

COURSE DESCRIPTION (a selected partial listing of courses)

Graduate courses:

580 Introduction to Radiation Chemistry - The interaction of all types of ionizing radiation with matter and the resulting radiation-induced chemical reactions. (3 s.h.)

584 Topics in Radiation Biology - The current literature of radiation biology. (3 s.h.)

589, 590 Seminar in Radiation Science - Topics of current interest. (1 s.h. each)

591 Radiation and Radioactivity - Atomic theory, nuclear structure, radioactivity, interactions of radiation with matter, and other topics. (4 s.h.)

595 Fundamentals of Radiation Instrumentation - Principles of electronics as they pertain to analytical and research instruments in radiation and biological sciences. (4 s.h.)

596 Radiation Instrumentation and Dosimetry - Radiation dose measurement; principles of operation and application of all important types of radiation detectors; counting statistics; instrument calibration. (4 s.h.)

598 Special Topics in Radiological Health - Advanced topics of current interest; background radiation levels; radiation exposure standards; environmental radioactivity; and others. (3 s.h.)

571 Radioecology - Study of irradiation effects on natural communities. Emphasis on mineral cycling in natural systems. (3 s.h.)

601 Experimental Problems in Radiological Health - A series of problems requiring literature search, field and laboratory exercises, and written reports. (2 s.h.)

INSTITUTION: ST. LOUIS COMMUNITY COLLEGE AT FOREST PARK (FPCC)

PROGRAM: Radiologic Technology

DEPARTMENT: Life Science

DEGREE: Associate of Science (A.S.)

CONTACT:
Mr. Robert Rickey, Dean of Instruction
Mr. Dwayne TerMaat
St. Louis Community College at Forest Park
5600 Oakland Avenue
St. Louis, Missouri 63110
(314) 644-9325

PROGRAM DESCRIPTION:

PROGRAM STRUCTURE

Through a Kellogg grant in the early 1960s, the allied health needs of the St. Louis area were identified. Thus the Radiologic Technology program began in the fall of 1967. It is a 24 month program requiring four semesters and two summer sessions.

The Joint Review Committee (JRC) of the Council on Medical Education of the American Medical Association is responsible for the program's accreditation. Major factors that enter into its decision for or against accreditation are the facilities at the various affiliated hospitals and the types and variety of examinations done at each institution. Students may do their clinical experience at one of the 12 hospitals associated with the FPCC program.

During the first year, they attend classes three days a week (Monday, Wednesday, Friday) and participate in clinic two days (Tuesday and Thursday). In the second year, three days are spent on-site (Monday, Wednesday, Friday) and two (Tuesday, Thursday) at the campus. Students remain with one hospital for their 2,200 hours of clinical experience.

This combination of classroom and clinical experience enables the student to successfully pass the National Certification Examination given through the American Registry of Radiologic Technicians.

PROGRAM REQUIREMENTS

A "C" or better in Algebra and Biology and a 2.5 GPA are required of high school seniors for admission. Because of the program's structure, students can only begin in June of each year.

Acceptance is dependent upon an acceptable complete health examination including a tuberculin skin test.

CURRENT FACULTY, STUDENTS, GRADUATES

Presently 23 men and 49 women are enrolled in the two-year program. Three of the four faculty members have the responsibility for clinical supervision in addition to classroom and laboratory instruction. This insures that the students will be seen once every ten days by an FPCC representative. Each hospital also has appointed a member of its staff to act as a student coordinator. These 12 individuals meet with the college representatives monthly.

Most students have 1 - 2 years of experience (occupational and/or college) before entering the program. They have experienced no problem securing a job after graduation. There is a shortage of radiologic technology trained people in the St. Louis area. FPCC graduates 30 students a year in this program.

Facilities include two X-ray machines, one of which is activated. Students practice positioning of the body with phanthoms (life-size manikins) that duplicate human tissue density and organ placement. This eliminates the danger of repeatedly exposing the human body.

PROGRAM PROJECTIONS

The faculty sees no increase in the number of students. Enrollment is limited by the hospital facilities. They do see a potential change in the curriculum. Ideas presently being considered are: more classroom work before the clinical portion of the training begins; and students being placed in more than one hospital for their clinical work. Clinical Objective Evaluation (COE) has been field tested and could become part of the competencies testing should the curriculum emphasis change.

COURSE DESCRIPTION

33.100 Positioning I - In-depth coverage of radiographic positioning and examination procedures for the upper and lower extremities, shoulder and pelvic girdles, bony thorax and vertebral column. (3 s.h.)

33.101 Positioning II - A continuation of 33.100 covering radiographic positioning and examination procedure for the skull, respiratory system, abdomen, digestive and urinary systems. (3 s.h.)

33.102 X-Ray Film Critique I - A critical analysis of the radiograph in the examination of the upper extremities, lower extremities, and the shoulder girdle. (1 s.h.)

33.103 X-Ray Film Critique II - A continuation of 33.102 covering the examinations of the pelvic girdle, bony thorax, vertebral column and the skull. (1 s.h.)

33.104 X-Ray Film Critique III - A continuation of 33.103 completing the skull and also covering the respiratory system, abdomen, and portions of the digestive system. (1 s.h.)

33.105 X-Ray Film Critique IV - A continuation of 33.104 completing the digestive and urinary systems. (1 s.h.)

33.153 Radiologic Technology I - This course is intended to give the beginning student basic knowledge in radiation protection, darkroom chemistry and technique, and an in-depth coverage of exposure factors, quality of radiographs, and critical analysis of the radiograph. (2 s.h.)

33.154 Radiologic Technology II - A continuation of Radiologic Technology I in which the student will be given technical consideration of radiographic exposure factors. (2 s.h.)

33.155 Radiologic Technology III - A study of specialized and highly technical procedures carried out in the department of radiology including the use of special equipment and opaque media. (3 s.h.)

33.156 Radiologic Technology IV - A study of intraoral radiography; advanced technical consideration of radiographic exposure factors and principles of administration and supervision in a department of radiology. (2 s.h.)

33.157 X-Ray Physics - A study of the fundamentals of magnetism, electricity, and radiation; construction and routine maintenance of equipment to permit detection and correction of simple difficulties which interfere with or prevent the proper function of the equipment or accessories. (2 s.h.)

33.159 Radiologic Pathology - This course is a presentation of the more commonly encountered lesions of the human body as seen through the medium of x-ray. Anatomy and physiology of pathologic processes are presented by body systems as a means of exploring the rationale of many intricate radiologic examinations. (2 s.h.)

33.161 Nuclear Medicine Technology - The fundamentals of radioisotope technology and the role of the technologist in their use are covered in this course. (2 s.h.)

33.170 Radiobiology - A course emphasizing the effects of radiation upon tissue and tissue recovery rate. (2 s.h.)

33.173 Fundamentals of Radiologic Technology - The essentials of medical technology, body mechanics, medical ethics, radiation protection, nursing essentials and darkroom procedures. (3 s.h.)

33.174 Clinical Education I - Observation in all aspects of the radiology department. Eight hours each week in a hospital radiology department. (1 s.h.)

33.175 Clinical Education II - Practicum in basic radiographic positioning. Sixteen hours each week in a hospital radiology department. (1 s.h.)

33.176 Clincial Education III - Practicum in radiographic positioning and the use of contrast media. Sixteen hours each week in an hospital radiology department. (1 s.h.)

33.177 Clinical Education IV - Continuation of practical education in all routine phases of radiologic technology. Forty hours each week in a hospital radiology department. (2 s.h.)

33.178 Clinical Education V - Practicum in the operation of specialized equipment used in highly technical procedures. Twenty-four hours each week in a hospital radiology department. (1 s.h.)

33.179 Clincial Education VI - A continuation of clinical education in all phases of radiologic technology. Twenty-four hours each week in a hospital radiology department. (1 s.h.)

INSTITUTION: SOUTHERN TECHNICAL INSTITUTE

PROGRAM: Nuclear Safety

DEPARTMENT: Electrical Engineering Technology

DEGREE: Associate of Science (A.S.)

CONTACT: Professor Julian R. Lee
Southern Technical Institute
534 Clay Street
Marietta, Georgia 30060
(404) 424-7371

PROGRAM DESCRIPTION:

PROGRAM STRUCTURE

Although the two-year option, which began in the fall of 1974, may culminate with an A.S. degree, most of its students continue in the four-year Electrical Engineering Technology program which leads to a Bachelor of Engineering Technology degree. Approximately half of those earning this degree are satisfying the requirements for two separate options.

Nuclear Safety requires that the student be proficient in electronics, in radiation physics, in principles of health physics, and in applied health physics. Graduates will be qualified for technological positions in development, testing, monitoring, research, sales, and maintenance in the nuclear field. Such positions as radiation-instrument technologist, and health-physics monitor can be filled by the graduates of this program.

Southern Tech is a division of nearby Georgia Institute of Technology so it has access to the nuclear reactor and nuclear instrumentation there. Southern Tech has its own reactor simulator, air quality monitoring system (sensitive to ambient radiation), thermoluminescent dosimeter reader, and numerous radiation counters. It is important to note that although students are learning techniques of operating a nuclear reactor, being a reactor operator is an occupation which requires licensing for the specific nuclear reactor on which one will be employed to operate. This requires an examination as well as a satisfactory demonstration of expertise.

PROGRAM REQUIREMENTS

Students wishing to be admitted to Southern Tech should complete three credits of English, two of algebra, one of plane geometry, and two of science during high school. Applicants must be high school graduates or the equivalent (GED). All freshman applicants must submit Scholastic Aptitude Test scores. Students who have deficiencies in one or more of the admission requirements may be admitted to Special Studies subject which supplement the high school record.

Prior to enrolling in nuclear safety, three prescribed physics courses must be completed. The curriculum in this option is inflexible rather than being suggestive. First year students must enroll in nine quarter hours of English, eighteen hours of mathematics including a course in computer programming, fifteen hours of chemistry and physics, in addition to two hours of engineering drawing and six of circuit analysis. The second year plan is outlined in the Course Description; however, generally, it requires thirty-two hours of electronics, three hours of technical writing, five hours entitled Heat, Sound, Light and Modern Physics. Thirteen hours refer specifically to radiation: Introduction to Nuclear Radiation, Principles of Health Physics, and Applied Health Physics. Graduates of this option must satisfy the requirements of the examination on the Constitution and Government of the United States and Georgia as required by state law.

CURRENT FACULTY, STUDENTS, GRADUATES

One faculty member coordinates, plans, and provides radiation/nuclear instruction for this option. When he is unable to be on campus to fulfill these responsibilities, a designated faculty member from physics substitutes for him. Additional instructional support comes from the other departments in which requirements of this program are offered.

Each of the ten students who are enrolled intends to pursue a B.E.E. degree, and upon graduation nearly half will be employed as engineers. Often times people who have enrolled in nuclear safety were in the military or have come from other institutions which do not have such an option.

The enrollment figure is down substantially from 1976's level of seventeen. This, it is felt, is in direct response to the negativism which has been generated by the controversy over the use of nuclear energy. Although a recruitment effort is going on, it is, for the large part, judged unsuccessful.

Follow-up questionnaires were sent to former students, but there was only minimal response to it. The Placement Office estimates that there exist ten positions in the field of radiation for each person who completes this option. Nearly all of those who do accept related positions are working for private firms rather than the government because salaries are much higher in the private sector.

PROGRAM PROJECTIONS

There is a need to add a course in the area of law as it pertains to the use of nuclear energy, one in reactor technology (repair and operations), and one in radiobiology. It is hoped that sufficient enrollment increases will occur to warrant acquiring additional faculty and facilities, and eventually to allow nuclear safety to attain department status and lead to a four-year degree, the Bachelor of Nuclear Engineering.

In addition to extending nuclear safety to a four-year program, officials would like to add one program in nuclear reactor operations in the Department of Mechanical Technology.

COURSE DESCRIPTION

EET 272 Introduction to Semiconductor and Electronic Devices - Physics and conduction properties of insulators, conductors, and semiconductors. Single stage circuits using graphical and analytical techniques. (6 q.h.)

EET 274 Circuit Analysis - Circuit theory and practice as applied to single-phase ac circuits. Response of RLC networks; impedance and admittance functions; complex notation, rms and average values; equivalent circuits. (6 q.h.)

EET 300 Semiconductor Circuits and Devices - Static and dynamic characteristics of semiconductor diodes, transistors, unijunctions, silicon controlled rectifiers, and other semiconductor devices. Transistor circuit analysis using methods of four-terminal network analysis with emphasis on h and t parameters. (6 q.h.)

EET 301 Computer Fundamentals - Digital computer systems; number systems, application of logic circuits to computer design; introduction to Boolean algebra. Logical design of digital computers. (4 q.h.)

EET 302 Circuit Analysis - Continued study of circuit theory and practice. Network theorems, elementary transients, resonant circuits, and coupled circuits. (4 q.h.)

EET 340 Pulse and Digital Circuits and Applications - Linear and nonlinear circuits used in generation and shaping of waveforms, including design and analysis of multivibrators, clippers, clampers, and logic circuits. Application to digital techniques such as computing telemetry and measurement systems. Primary emphasis on semiconductor circuits including integrated-circuit techniques. (6 q.h.)

ENGL 231 Technical Writing - Fundamentals of technical writing style, practicein preparing reports of types likely to be used by engineering technologists. (3 q.h.)

PHYS 203 Heat, Sound, Light and Modern Physics - Theories of heat, sound and light and their simpler applications. Includes thermometry, calorimetry, heat transfer, thermodynamics, reflection and refraction of light, mirrors, lenses, interference, diffraction, and polarization. Brief considerations of relativity, atomic structure, radioactivity, and nuclear energy. (5 q.h.)

PHYS 375 Introduction to Nuclear Radiation - Physical basis for understanding effects of ionizing radiation on matter. Developing of a philosophy of radiation for individuals and environment, and for radiation-protection programs. (5 q.h.)

PHYS 377 Principles of Health Physics - Introduction to health physics. Biophysical bases of radiation protection criteria. Philosophy and methodology of Nuclear Engineering Technology. Operation of a nuclear reactor using nuclear-reactor simulator. (4 q.h.)

PHYS 379 Applied Health Physics - Health physics in our society. Control of radiation in industry and medicine. Personnel monitoring, bioassay, air sampling and respiratory protection, radiation surveys of nuclear reactors, accelerators, radioisotope laboratories, and x-ray installations, emergency planning and control of emergency conditions, professional ethics and judgment, and government regulation of ionizing radiation. (4 q.h.)

INSTITUTION: THE PENNSYLVANIA STATE UNIVERSITY

PROGRAM: Nuclear Engineering Technology

DEPARTMENT: General Engineering

DEGREE: Associate Degree in Nuclear Engineering Technology

CONTACT: Dr. Warren F. Witzig
Head, Department of Nuclear Engineering
231 Sackett Building
The Pennsylvania State University
University Park, Pennsylvania 16802
(814) 865-4911

PROGRAM DESCRIPTION:

PROGRAM STRUCTURE

This two-year associate degree program was initiated in the fall of 1970 at the University's Altoona Campus with the Hazleton and McKeesport Campuses aiding the program in the fall of 1974. The program's sixth term is taken at the University Park Campus. The program is designed to train versatile, well-equipped nuclear technicians who can quickly become valuable and effective members of engineering and reactor operations teams. Nuclear technicians assist professional engineers in radiation safety, reactor operations, radiosotope handling, nuclear and control instrumentation, fuel fabrication, and health physics. They perform routine research, development, testing manufacture, and maintenance tasks.

While at the Altoona and other campuses, the student receives specialized instruction in mathematics, physics, electricity and electronics, chemistry,and communications. During the sixth term at the University Park Campus, the Nuclear Engineering Department faculty provides instruction. Extensive use if made of the Breazeale Nuclear Reactor Facility to familiarize students with the components and systems in a nuclear power plant.

PROGRAM REQUIREMENTS

Applicants to the program are required to have completed fifteen Carnegie units of preparatory work at an accredited secondary school. Graduates of three-year senior high schools need only twelve units of work. Required are three units of English and two units of mathematics. One unit of mathematics must be in algebra and the other in any combination of advanced algebra, plane geometry, solid geometry; or trigonometry.

A total of 73 credits completed are required to earn the Associate Degree in Nuclear Engineering Technology. Students take over the six required terms courses in English, mathematics, physics, computer science, chemistry, electrical engineering, mechanical engineering, speech communication, and nuclear engineering. Electives are required in humanities and in the social sciences. Sixth term lectures by faculty of the Nuclear Engineering Department cover various reactor types, with emphasis on fuel heat removal and power generation, shielding, fuel fabrication, reprocessing control systems, steady-state reactor theory, and reactor safety. Laboratory sessions provide "hands-on" experience with basic reactor experiments and radiation measurements. Students take 12 credits of Nuclear Engineering during the Sixth Term.

Institutional aid (scholarships and loans) or federal aid (Supplemental Educational Opportunity Grants,etc.) are available to students. A limited number of freshman scholarships are awarded to some students.

CURRENT FACULTY, STUDENTS, GRADUATES

Faculty from the General Engineering Department and the Nuclear Engineering Department cooperate in presenting instruction to students enrolled in the program. Because the courses are offered at a variety of campuses, it is not possible to determine how many faculty are involved in teaching the curriculum.

There are currently 30 students enrolled in the Nuclear Engineering Technology Program (3-4 female). This represents a sizable decline from the total enrollment of 61 during the fall term, 1976. The May, 1977 graduates numbered 20.

Ninety percent of the program's graduates enter the job market and ten percent continue on for higher degrees at Penn State's University Park Campus. About 67% find jobs in the private sector (industry, utilities, and architectural engineering firms) and 33% find positions in the government. Employment for graduates is tending to be increasingly difficult to obtain and is radically different from the situation three years ago in which the anchorman graduate had three job offers by the time he or she graduated.

PROGRAM PROJECTIONS

Reactor construction and operation continue at a high level, which assure a stable enrollment and graduate projection for this program.

COURSE DESCRIPTION

800 Nuclear and Atomic Science - Introduction to the theories of atomic and nuclear structure and electromagnetic radiation. (2 s.h.)

801 Radiological Safety - Discussion of basic radiation dose units, radiation monitoring techniques, biological effects of radiation, and AEC regulations. (2 s.h.)

802 Elements of Nuclear Technology - Study of nuclear radiations, nuclear interactions, neutron diffusion, and reactor materials. (2 s.h.)

803 Elements of Nuclear Power Generation - Survey of various reactor types with emphasis on fuel heat removal and power generation, shielding, fuel fabrication and reprocessing. (3 s.h.)

804 Introduction to Reactor Technology - Steady state reactor theory, kinetic behavior of reactors and reactor control systems. (3 s.h.)

805 Principles of Measurement - A study of measurement in the nuclear industry, including the instruments used, accuracy of measurement, and statistical justification. (3 s.h.)

812 Nuclear Technology Laboratory - Laboratory study of radiation measurements and the diversified application of nuclear techniques. (3 s.h.)

814 Reactor Technology Laboratory - Laboratory study of basic reactor experiments, control rod calibration, critical experiment, etc. (3 s.h.)

830 Selected Topics in Nuclear Engineering Technology - Individual group work in nuclear engineering technology for students with specific occupational objectives. (3 s.h.)

INSTITUTION: THE PENNSYLVANIA STATE UNIVERSITY

PROGRAM: Nuclear Engineering

DEPARTMENT: Nuclear Engineering

DEGREE: Bachelor of Science in Nuclear Engineering
Master of Science in Nuclear Engineering
Master of Engineering in Nuclear Engineering
Doctor of Philosophy

CONTACT: Dr. Warren F. Witzig
Head of Nuclear Engineering Department
231 Sackett Building
The Pennsylvania State University
University Park, Pennsylvania 16802
(814) 865-4911

PROGRAM DESCRIPTION:

PROGRAM STRUCTURE

The Nuclear Engineering Department first offered an M.S. program in 1959 following acquiring a research reactor and associated facilities from support provided by President Eisenhower's "Atoms for Peace" program in 1955. The baccalaureate degree program was first initiated in 1968. Undergraduates receive instruction in energy removal and conversion, neutron physics, materials science, instrumentation and control, and chemistry. Emphasis in the program is on the environmental interfaces, the fuel cycle, cost-benefit criteria, and quality assurance.

Nuclear engineers can obtain positions in research, development, design, manufacture, or operation of nuclear systems, including nuclear fission reactors, fusion devices, and radioisotopic generators.

The College of Engineering of the Pennsylvania State University and the Graduate School of Public Health of the University of Pittsburgh have developed a joint five-year program leading to a Bachelor's Degree in Nuclear Engineering and a Master's degree in Radiation Health. Students enter the program at the University Park campus as freshman enrolled in Nuclear Engineering. At the satisfactory conclusion of a normal four-year program, the students graduate with a degree in Nuclear Engineering. Those eligible will then be admitted upon application, to the Radiation Health Department of the Graduate School of Public Health of the University of Pittsburgh. At the University of Pittsburgh, courses can be selected in Health Physics, Radiation Biology, and Medical

Applications. Within eleven months upon entering the graduate program a master's degree in Radiation Health (M.Sc.Hyg.) can be earned.

The Nuclear Engineering Department has one of the most complete and modern university reactor facilities in the United States. The laboratory complex includes the Penn State TRIGA MARK III Reactor, the Combalt-60 Radiation Facility, two hot cells, a radiochemistry laboratory, an extensive array of radiation sources and counting equipment, and much more. The Department is currently constructing a new fast reactor subcritical assembly.

PROGRAM REQUIREMENTS

In order to enter the undergraduate program in the College of Engineering, three secondary units of English, three units of math, one unit of science, and eight units of other courses are required. The mathematics requirement includes 1½ units of algebra, one unit of plane geometry, and ½ unit of trigonometry. To enter the graduate program, students with a 2.50 junior-senior average and with an appropriate course background will be considered for admission.

The undergraduate program requires 21 required credits in Nuclear Engineering and six additional credits in the Nuclear Engineering option. Additional courses in engineering, chemistry, physics, math, and humanities complement and supplement the nuclear engineering core. A total of 137 credits are required to earn the B.S. degree in Nuclear Engineering.

A minimum of 30 credits is required for the Master of Science degree and students may decide whether to prepare a scholarly paper or a research thesis. The thesis is worth six credits. Six credits of graduate courses in the major field may be taken to earn the M.S. without thesis.

The Master of Engineering degree also requires a minimum of 30 creits but no thesis. Instead, an engineering paper about a selected phase of engineering is prepared and corresponds to a typical first assignment to an engineer working in industry.

The Ph.D. degree requires 55-65 credits of 400-500 level courses plus about 30 credits of Nuclear Engineering 600 courses. The doctorate program is worked out in conjunction with the major advisor and the Ph.D. doctoral committee. One half of the course credits are in math, physics, and a minor engineering field, and the other half are composed of Nuclear Engineering Department courses. The major requirements for the Doctor of Philosophy candidate are:

1. Successful completion of a candidacy examination.
2. Demonstrated proficiency in two languages pertinent to his/her Ph.D. program. One of these must be English.

3. Successful completion of a comprehensive examination.
4. Completion of a doctoral thesis.
5. Successful completion of a final oral examination on the thesis work.

B.S. degree students may participate in a co-op program with architectural engineering firms and utilities. Only one to two students are involved in this program. In the spring term the department takes a field trip to several nuclear power installations. Several seminars are scheduled during the year and both undergraduates and graduate students are encouraged to attend.

The traditional sources of financial aid (loans, scholarships, federal programs) are available to undergraduates. The Nuclear Engineering Department has several half-time assistantships available which includes a stipend and a grant-in-aid to cover all tuition. Two Department of Energy funded traineeships are available. Trainees carry five to seven course credits perterm receive stipends, and usually receive grants-in-aid.

CURRENT FACULTY, STUDENTS, GRADUATES

Sixteen faculty members teach the department's curriculum Faculty devote about 20 percent of their time to research activities. Two faculty members are supported entirely by research funding. Most research funding comes from the Department of Energy, the National institutes of Health and from utilites. Current environmental related research includes thermal pollution control, SO_2NOX particulate removal, and effects of radiation on boiling.

There are currently (Fall, 1977) 180 students enrolled in the B.S. degree program of whom about nine (5%) are female. About 40 students (no females) are enrolled in advanced degree programs. There are very few part-time students enrolled at Penn State primarily because of the remoteness of the University Park Campus. It is estimated that 40 students annually receive the B.S. degree and 18 students receive advanced degrees. Enrollment has increased slightly since the Fall Term, 1976.

Students earning baccalaureates in the program are encouraged to apply to other educational institutions for higher degrees. Approximately twenty percent of the baccalaureate and masters graduates continue on for advanced degrees. Department officials estimate that two thirds of the Department's graduates obtain jobs in the private sector (industry, utilities, consulting) and one-third find positions in government. A survey was conducted of 42 1976-1977 baccalaureate graduates and it was found that: 22 were employed by industry; 2 are in the military; 6 are attending graduate school, and the status of 12 are unknown.

PROGRAM PROJECTIONS

It is not anticipated that the program will undergo significant changes within the foreseeable future other than common evolutionary modifications. Within the next five to ten years, it is anticipated that the number of faculty may increase by ten percent or two persons. Increased emphasis may be taken in nuclear medicine, environmental impact analysis, computer modelling, and pathways demand for radioisotope transport.

COURSE DESCRIPTION

(the following is a partial listing of courses)

Undergraduate courses:

NucE 200 Elements of Nuclear Engineering - Introduction to analytical and experimental aspects of nuclear engineering. (3 s.h.)

NucE 405 Applied Nuclear and Radiochemistry - Fundamentals and interdisciplinary applications of Nuclear and Radiochemistry with laboratory work using a variety of radiation measurement instruments. (3 s.h.)

NucE 408 Radiation Shielding - Radiation sources in reactor systems; attenuation of gamma rays and neutrons; point kernel methods; deep penetration theories; Monte Carlo methods. (3 s.h.)

NucE 415 Radionuclear Applications - For engineering and science students. Emphasizes research and industrial applications of radionuclear techniques; includes instruction in utilizing university's irradiation facilities. (3 s.h.)

NucE 420 Radiological Safety - Ionizing radiation, biological effects, radiation measurement, dose computational techniques, local and federal regulations, exposure control. (3 s.h.)

NucE 425 (Bio E 425) Radiographic Imaging - theories of image formation and quantification. Radiation sources, interactions, sensing, signal processing, image display X-rays, gamma rays, neutrons, infrared, acoustical applications. (3 s.h.)

NucE 428 Radioactive Waste Control - Nature, sources, and control of radioactive wastes; theory and practice of disposal processes. (3 s.h.)

Graduate courses:

NucE 501 Reactor Engineering - Reactor controls, shielding of nuclear reactors, stress analysis of reactor materials, power cycle analysis, breeding, and advanced design considerations. (3 s.h.)

NucE 507 Interaction of Radiations with Matter - Theory of the processes by which gamma rays, neutrons, and charged particles interact with electrons, atoms, and nuclei. (3 s.h.)

NucE 509 Radiation Damage in Solids - Production of defects by high-energy particles; nature of defects; diffusion and annealing in solids; macro property changes. (2 s.h.)

NucE 511 Nuclear Reactor Materials - Philosophy, selection, technology, use economics, and performance of materials of major interest in nuclear power reactors today. (3 s.h.)

NucE 520 Reactor Analysis - Physical principles and mathematical methods of reactor analysis. (3 s.h.)

INSTITUTION: UNIVERSITY OF FLORIDA

PROGRAM: Radiological Sciences

DEPARTMENT: Nuclear Engineering Sciences, Environmental Engineering

DEGREE: Master of Science
Master of Engineering

CONTACT: Dr. Genevieve S. Roessler
Department of Nuclear Engineering Sciences
University of Florida
Gainesville, Florida 32611
(904) 392-1401, (904) 392-1404

PROGRAM DESCRIPTION:

PROGRAM STRUCTURE

This graduate program is conducted by both the Department of Environmental Engineering, which designed the original option in 1958, and by the Department of Nuclear Engineering Sciences, which became involved in 1960. The program coordinator is a member of the faculty of the Department of Nuclear Engineering Sciences.

Students have a number of alternatives from which to choose in selecting their course of study. Depending on one's academic background, she/he may pursue either a Master of Science (M.S.) degree or a Master of Engineering (M.E.) degree. Each degree is offered by both the Department of Nuclear Engineering Sciences and the Department of Environmental Engineering, each with slightly unique curriculum requirements. Based on a student's career objectives, she/he may elect to major in Health Physics or Medical Radiation Physics.

Students who graduate in Health Physics will likely find employment with industry, universities or colleges, or government in the areas of radiation protection, research, and instrumentation design and marketing, and waste management. Those who graduate in Medical Radiation Physics are qualified to work in hospital radiation physics departments and in any facility which utilizes radiation in a medical context. Medical radiation physicists will assist physicians in formulating appropriate radiological treatment and diagnostic plans and they will supervise the use, care, and selection of related instrumentation. Considerable overlap exists in the tasks which each respective graduate is capable of performing.

The University of Florida has its own nuclear reactor facility which houses a 100 KW nuclear reactor; 4 Me V Van de Graff accelerator; IPM 1800 digital computer; selected auxiliary computers; and a sizable inventory of additional nuclear instrumentation. The College of Medicine makes available its X-ray diagnosis, radiation therapy, nuclear medicine and other medical instrumentation. The College of Medicine also provides laboratory and instructional support. The Department of Environmental Engineering offers students access to its low-level radiation counting and preparation room; radiation surveillance laboratory and counting room; three research laboratories; an electronics shop; and an isotope storage room and vault.

PROGRAM REQUIREMENTS

The Graduate School requires all entrants to have taken the Graduate Records Examination prior to making application, to have satisfactory undergraduate records, and letters of recommendation.

Students who wish to pursue the M.S. degree may have academic backgrounds from any of the basic sciences such as physics. Students who are seeking the ECPD-accredited M.E. degree must have a diploma from an ECPD-accredited undergraduate engineering program or the equivalent. Those individuals who have degrees in fields other than engineering and wish to get the M.E. degree must take sufficient undergraduate engineering coursework so as to make their academic transcript equivalent.

Twenty-eight credits of core courses are common to both majors. Medical Radiation Physics requires thirteen credits which are specific to the field of radiation physics. Health Physics requires eleven credits in addition to the core. Depending on a student's professional objectives, she/he may elect to substitute twelve credits, nine of which are nuclear engineering sciences, including a six-hour (minimum) special project, in place of a fifteen-credit (maximum) thesis project. In these instances, the completion of fifty-three or fifty-four credits will meet the minimum requirements for a non-thesis degree. Students who are enrolled in the Department of Environmental Engineering must satisfy approximately twelve credits of environmental engineering courses, depending on their background.

CURRENT FACULTY, STUDENTS, GRADUATES

The faculty is currently composed of seven full-time people. Approximately 60 percent of their responsibilities are given to research, and the remaining 40 percent lies with teaching. Students may satisfy elective hours in the College of Medicine, Department of Biology, and/or Department of Zoology and in this way these departments have a supportive role in the two major fields.

Over one-half of the thirty-two full-time and four part-time students enrolled in both of the majors are Florida residents. There is an even split of sixteen full-time students in each program. All but four of the full-time students receive financial assistance from the Department of Energy, the Air Force, the Army, the Navy, the Pan American Health Organization, and graduate fellowships and research assistantships. The four part-time students are employed full-time outside the university.

There has been an average of twelve to fourteen graduates per year from both of these programs. The enrollment figure for this department may be considered stable because given the current staff size and funding level, this is the maximum number which can be effectively trained.

Officials report more employment opportunities available in all sectors of the field than there are graduates to fill them. Most students do not use the campus placement service to locate positions; rather, a file is kept in the coordinator's office containing leads on employment (i.e., professionals who have contacted her asking for candidates, and contracts she and other faculty members have made on behalf of the students). While there has been no formal follow-up study conducted on the students, because of the program's comparatively small size, close associations are formed among students and faculty, and in this way they have learned what each of the graduates has done in the way of finding employment. It should be noted that a small number of graduates has continued their schooling in medical school, and these people have found the Medical Radiation Physics major to have been excellent preparation.

PROGRAM PROJECTIONS

It is felt that there is a need to augment the Medical Radiation Physics major with a clinical practicum in the hospitals especially with respect to the area of diagnostic X-ray techniques.

It is possible that the Health Physics major will soon be accredited by the Health Physics Society, and the Medical Radiation Physics major by the American Association of Physicians in Medicine.

ADDITIONAL INFORMATION

Communication skills of the graduate students have been found to be critically deficient in many cases, so much so that a committee has been formed to examine the problem and devise an appropriate course of action for remediation.

COURSE DESCRIPTION

Core Curriculum:

NES 500 Fundamentals of Reactor Engineering - Nuclear reactor concepts, instrumentation, operations, fuels, materials, and shielding. (4 q.h.)

NES 540 Nuclear Radiation Detection and Instrumentation - Interaction of radiation with matter, radiation detector systems, pulse shaping, amplification, amplitude and time-analyzing circuitry. Counting and measuring devices and control systems for nuclear reactors. (4 q.h.)

NES 584 Radiation Biology - Effects of radiation on humans. Use of radiation in treatment of disease. (5 q.h.)

NES 586 Radiation Biology Lab-(2 q.h.)

NES 641 Radiological Techniques - Application of radiological techniques to environmental engineering. (5 q.h.)

NES 690 Nuclear Seminar - Current research trends in nuclear-related industry. Government and research establishments. (1-4 q.h.)

NES 691 Special Projects in Nuclear Engineering Sciences - Non-thesis research projects. (1-9 q.h.)

NES 699 Research for Master's Thesis - (1-15 q.h.)

Health Physics requirements:

NES 580 Bionucleonics - Application of radiation and radioactivity to human biomedical problems. Benefits to man as opposed to potential hazards. (3 q.h.)

ENV 642 Radioactive Wastes - Source, treatment, and disposal of radioactive wastes. Prevention of environmental contamination. (4 q.h.)

ENV 643 Electronic Product Radiation - Hazards, application of standards and engineering controls for any electromagnetic or particulate radiation from an electronic device. (4 q.h.)

ENV 671 Special Problems in Environmental Engineering - (1-12 q.h.)

Medical Radiation Physics requirements:

NES 680 Radiological Physics - Nature of X-rays. X-ray tubes for diagnosis and treatment. Image amplifiers. Quality of X-rays, half-value layer, and X-ray filters. High energy electron accelerators and isotope therapy units. (4 q.h.)

NES 682 Medical Radiation and Dosimetry - Dosimetry instrumentation including ion chambers, semiconductor and luminescent devices. Measurement in roentgens. Measurement of absorbed radiation energy. Manual and computer techniques in treatment planning for external beam therapy and implanted sources. (4 q.h.)

NES 686 Nuclear Medicine Instrumentation and Procedure - Theory, evaluation, and applications of detecting and imaging systems in nuclear medicine. Uses of radionuclides in medicine for radiopharmaceutical preparation and "in vivo" and "in vitro" diagnostic procedures. Internal radiation dosimetry. (5 q.h.)

Environmental Engineering requirements:*

ENV 520 Environmental Biology - Basic cellular organization and processes related to waste treatment. Role of environmental engineer in maintaining freshwater, marine, and terrestrial ecosystem stability. (4 q.h.)

ENV 630 Environmental Chemistry - Water treatment, chemical composition of natural waters. Physical and organic chemistry applied to aqueous and gaseous systems. (5 q.h.)

ISE 350 Computer Programming for Engineers - Computer programming and the uses for large scale digital computers. (3 q.h.)

* unless waived by undergraduate training.

INSTITUTION: UNIVERSITY OF KANSAS

PROGRAM: Radiation Biophysics

DEPARTMENT: Radiation Biophysics

DEGREE: Bachelor of Arts in Radiation Biophysics (B.A.)
Bachelor of Science in Radiation Biophysics (B.S.)
Master of Science in Radiation Biophysics (M.S.)
Doctor of Philosophy in Radiation Biophysics (Ph.D.)

CONTACT: Dr. Edward I. Shaw, Chairman
Department of Radiation Biophysics
University of Kansas
140 Nuclear Reactor Center
Lawrence, Kansas 66045
(913) 864-3867

PROGRAM DESCRIPTION:

PROGRAM STRUCTURE

Historically, the twelve-year-old Department of Radiation Biophysics at the University of Kansas began as part of an interdisciplinary program in the 1940s. By 1956, faculty members were being acquired who had no official link with any departments. In 1965, the department was formally established. Its basic training objectives blend academic and technical interests with a basic science curriculum.

The Department of Radiation Biophysics is located in the Nuclear Reactor Center because of its close academic and operational relationship to the 250 KW nuclear reactor housed there. Many of the faculty and graduate students in the department comprise the operational Radiation Safety Services which provide for surveillance of the reactor as well as all other radiation facilities and radioisotope laboratories on campus. Other facilities available to students and staff in the program include a three-room X-ray suite; a teaching laboratory equipped for instruction in the handling of unsealed sources and performance of radioactive assays, tracer experimentation, and experiments with radiation detectors in general; seven laboratories equipped for research in radiation chemistry, radiation dosimetry, and radiobiology; a machine shop; and a chemical laboratory. Though the department's facilities and equipment are extensive, according to faculty personnel, they are also fast becoming vintage models.

Current research funding totals $90,000. Sources include National Institute of Health grants, Mid-American Cancer, and a training grant from the Energy Research and Development Administration (now the Department of Energy) that supports two students.

PROGRAM REQUIREMENTS

The degree of Bachelor of Arts with a major in Radiation Biophysics permits the student to develop a knowledge in the interdisciplinary aspects of science with a greater degree of flexibility in the design of the program than is provided in the Bachelor of Science curriculum. The requirements for a B.A. major in this program include a minimum of 20 hours in radiation biophysics, and courses in mathematics, organic chemistry, and atomic or modern physics.

The degree of Bachelor of Science with a major in Radiation Biophysics is effectively a major in natural science with emphasis on the relationships between various branches of science. Because of its special concerns with the application of physical phenomena and reasoning to the problems of biology and medicine, the program provides an ideal major for the premedical student, the future radiological physicist or health physicist, and the hospital radioisotope technician, as well as for prospective graduate study. Coursework in biology, chemistry, mathematics, physics, and radiation biophysics and in general education areas (English, humanities, foreign languages, social sciences, speech, etc.) are required. (credit hours total 107-126 s.h. depending on foreign language proficiency.)

Admission to the graduate program requires proficiency in mathematics, physics, chemistry, and biology, or completion of coursework to correct deficiencies in these areas. For the M.S. degree, a student must complete 30 credit hours in Radiation Biophysics (702, 704, 712, 720, 722, 760, 810, 899) and supplemental courses to be chosen in conformity with the needs and special interests of the students. A thesis is required. Requirements for the Ph.D. in Radiation Biophysics specify that a student, prior to taking his/her comprehensive examinations, must attain proficiency in at least one research skill which has relevance to the proposed area of research (e.g., mathematics, computer science, foreign language) and have completed the minimum requirements for the master's degree, coursework in differential equations, mathematics, genetics, physical chemistry, biochemistry, quantum physics or chemistry, electricity and magnetism, nuclear physics, and the departmental course in general biophysics. In addition, the student must complete at least eight hours of 800 or 900-level courses in the department and supplementary courses chosen in conformity with the special interests of the student, pass comprehensive exams, and submit an acceptable dissertation.

CURRENT FACULTY, STUDENTS, GRADUATES

Four full-time and one part-time faculty with appointments in the Department of Radiation Biophysics and several adjunct professors in the medical program at the University of Kansas serve twenty full-time and four part-time graduate students (25 percent women) and sixteen declared undergraduate majors. A number of students enter the program from junior colleges while some have engineering backgrounds from the service and are sent by the military for further training. Numbers of graduate students (20-30 M.S. and Ph.D.) fluctuate depending on the funding and support the department can offer them.

Recruitment is based on the national reputation of the program, but diminishing sources of student support may entice potentially good students away from the University of Kansas and to schools where the money is available. In addition to the two ERDA training fellowships cited above, five or six students are supported by research grants to the department; one is a teaching assistant; some graduate students are supported by the miliary; and some by foreign governments.

An estimated 70 percent of the undergraduates pursue further schooling, and roughly 50 percent of the master's degree recipients return for the doctorate in Radiation Biophysics or in physics, medicine, biology, or chemistry. Of those who enter the labor force, virtually all obtain employment in their field; the job-student ratio is an enviable 5.5-1. Employment prospects for students with bachelor's degrees are usually with companies who then train these graduates as technicians. Persons with graduate degrees are considered to be technical professionals--individuals who combine academic orientations with technical skills.

Graduates are employed by nuclear regulatory commissions, nuclear power plants, the Environmental Protection Agency's Bureau of Radiological Health, government laboratories, state health agencies, hospital research labs, and private companies (as radiation specialists in protection, research, or product development). According to a study reported by the Health Physics Society, "career opportunities for students in Radiation Biophysics fall into three general categories: (1) radiation protection or health physics, (2) medical physics, and (3) basic research in biophysics and the biomedical sciences." A poll of society members indicated that in the first category alone, "19 percent are hired by industry, 27 percent by universities, 33 percent by state and federal governments, 5 percent by the military, 5 percent by hospitals (not including medical physicists), and 1 percent are self-employed." (Percentages refer to students. The study is available from the contact person at the University of Kansas.)

PROGRAM PROJECTIONS

With federal support for training declining, the task of maintaining 20-30 graduate students in Radiation Biophysics soon becomes very expensive for the sponsoring university. The cut in federal funds at the University of Kansas reduces any assurance that the program will last indefinitely. Unlike other environmental programs, Radiation Biophysics cannot depend on "bread-and-butter" undergraduate course enrollments for support. There is a large potential for increased enrollment with the growing personnel demands in nuclear power plants, state and federal agencies, and health and medical facilities. According to university personnel, however, an increased enrollment will demand (1) additional graduate student support (e.g., (2) modernization of equipment, (3) additional faculty (minimun of one), (4) funding for supplies and training materials, and (5) clerical support. The facilities at the University of Kansas can easily handle 30-40 graduate students if these needs are met.

COURSE DESCRIPTION

108 Radiation, Environment and Man - The interrelationship between man's production and use of power and energy: consequences for man and his environment. The characteristics of both natural and man-made radiations, particularly from nuclear power and the known and possible effects upon living systems are discussed. Radioactivity, radiation detectors, radiation effects in biological systems, radioactive tracer studies are examined in the lab. (3-4 s.h.)

Undergraduate and graduate courses:

700 Physical Foundations of Radiation Biology - This course is designed to present in a unified manner the aspects of radiation physics, and mathematics necessary for the fundamental concepts in radiation biology. (3 s.h.)

701 Radioisotopes - To prepare the student to understand the principles in the utilization of radioactive isotopes as tracers. A discussion of the properties of radioactive materials, radiations and their interaction with matter, methods of radiation detection, permissible exposure values, protective measures, design of tracer experiments, and applications. (2 s.h.)

702 Radiation Protection - The purpose of this course is to provide the student with an understanding of the health and safety measures required by governmental regulations related to the use of radioactive isotopes and high energy radiation sources. Protective measures, permissible dose concepts, hazard evaluation, safe handling techniques and general radioactive isotope laboratory procedures are discussed. (3 s.h.)

704 Radioactive Tracers and Instrumentation I - One semester basic course in the operation of most commonly used instrumentation measurement of radioactivity, techniques for handling unsealed sources of radioactive materials, some methods of preparation of radioactive samples, and simple design of tracer experiments. (2 s.h.)

708 Environmental Radiation and Nuclear Power - Study of radioactive materials in the environment with emphasis of those produced as a result of nuclear power production. Topics include natural radioactivity, the nuclear fuel cycle, transport mechanisms, siting criteria for nuclear facilities, U.S. A.E.C. Regulations and Regulatory Guides, and environmental sampling and radioassay methods. (2 s.h.)

781 Medical Physics II - A continuation of 780, but dealing with the application of non-ionizing radiations in medicine. Subjects covered include thermography, lasers, microwaves, and ultrasound, primarily in their role as diagnostic devices. Lectures will be supplemented with demonstrations and visits to medical facilities where certain of these devices are in use. The course is designed to give the prospective medical physicist a familiarity with the non-traditional areas of hospital physics that have become increasingly important in medical practice in the last few years. (3 s.h.)

Graduate courses:

810 Dosimetry and Shielding - Advanced treatment of the dosimetry of high energy ionizing radiations for medical and biological applications. Includes principles of cavity ionization measurements, calorimetry, chemical dosimetry, solid state dosimetry, dose distributions, and microdosimetry. Application of the principles of radiation absorption and attenuation to the design of protective shielding of radiation sources. (3 s.h.)

811 Radiation Dosimetry Laboratory - An advanced laboratory course designed to supplement the theoretical work of 810. It demonstrates experimentally the essential considerations of cavity ionization, the principles of chemical and solid state dosimetry, the production and measurement of X-rays and gamma rays, and neutron dosimetry. (2 s.h.)

920 Advanced Topics: Radiation Biology - These subjects will involve the discussion and interpretation of current literature for the purpose of introducing students to the most advanced concepts in the area. (2-3 s.h.)

922 Advanced Topics: Radiological Controls - Unifying course in which the advanced principles of radiation biology, radiation physics and chemistry, and general biophysics are utilized in the formulation of the philosophy of radiological control. Current concepts of these subjects are presented, the theoretical aspects of which comprise the bases for the development of the philosophy of radiation control. The student is oriented toward currently developing areas of research, the results of which affect the current concept of radiological control. (2-3 s.h.)

923 Advanced Topics: ____________________ - These subjects will involve the discussion and interpretation of current literature for the purpose of introducing the students to the most advanced concepts in each area. (2-3 s.h.)

925 Radiation Genetics - Study of current developments in radiation genetics; relationship of genetic damage to reproductive death and mutation of molecular mechanisms which lead to recovery from or repair of genetic damage in microorganisms and in mammalian cells; radiation-induced genetic effects in higher animals; genetics of radiated populations. (3 s.h.)

930 Nuclear Medical Physics - Application of principles of radiation physics, radioactive tracers and radiation biology to diagnostic and therapeutic problems. Comprises mainly student participation in actual laboratory procedures. (3 s.h.)

931 The Physics of Radiation Therapy - Application of the principles of radiation physics and radiation biology to the treatment of neoplastic lesions. Consists mainly of student participation in radiation therapy procedures. (3 s.h.)

932 The Physics of Diagnostic Radiology - The application of physical principles to problems involved in diagnostic procedures which use radiation as the investigative instrument. (2-3 s.h.)

940 Graduate Seminar - Discussion of published research reports or reports by staff members or students of research in progress. (1 s.h.)

950 Advanced Health Physics Laboratory - Application of theory of the evaluation of radiation procedures. Analysis of the various operations in each procedure based on the accepted methods of hazard control. (1 s.h.)

899 Radiation Biophysics Research - Original investigation on problem approved by the Radiation Biophysics Committee. For students seeking the master's degree. (1-12 s.h.)

999 Radiation Biophysics Research - Original investigation on problem approved by the Radiation Biophysics Committee. For students in the Ph.D. program. (1-12 s.h.)

INSTITUTION: UNIVERSITY OF LOWELL

PROGRAM: Radiological Health Physics/Radiological Sciences

DEPARTMENT: Radiological Sciences

DEGREE: Bachelor of Science (B.S.)
Master of Science (M.S.)

CONTACT: Dr. Jesse Y. Harris
Department of Radiological Sciences
University of Lowell
1 University Avenue
Lowell, Massachusetts 01854
(617) 454-7811 ext. 546

PROGRAM DESCRIPTION:

PROGRAM STRUCTURE

The University of Lowell offers two programs in radiation: radiological health physics at the undergraduate level and radiological sciences and protection at the graduate level. Although each program is offered only at the level indicated, they are similar in many characteristics and have the same program faculty. The B.S. program began in 1970 and the M.S. program was initiated in 1972.

The programs are interdisciplinary in nature and several departments offer courses which are relevant to the programs. Students are trained for professional positions in the fields of radiation safety and control. A summer internship is available in the undergraduate program in which a student may spend a summer working in a nuclear or radiation facility.

Research support for the program is provided by the University's Nuclear Center. This is also used in the internship program as a training facility.

PROGRAM REQUIREMENTS

Admission to the undergraduate program requires a high school diploma and it is recommended that applicants have adequate preparation in mathematics, chemistry, physics, and biology.

Requirements for admission to the M.S. program stipulate that an applicant must hold a bachelor's degree or equivalent from an accredited college or university where a uniformly high scholastic rating has been maintained. Students should have reasonable undergraduate preparation in math, chemistry, physics, biology, and nuclear and radiological sciences.

For the B.S. degree, a minimum of one hundred and twenty-two credit hours of course work, including thirty-nine credit hours in radiological health physics courses. Another thirty-five to thirty-seven hours are in supporting sciences and mathematics, twenty-three hours in university core requirements such as social sciences, humanities, and English, and twenty to twenty-two hours of electives. Most students also complete at least one summer in a health physics internship program, but this is not required for the degree.

An M.S. degree requires at least thirty credit hours of graduate course work, completion of a Master's thesis or Master's project, and a comprehensive written and/or oral examination. The curriculum must consist of five core courses in radiation safety and control, radiation biology, radiation physics, and radiation dosimetry, and research or advanced projects in radiological sciences and protection.

CURRENT FACULTY, STUDENTS, GRADUATES

There are a total of five faculty members participating in the program, three of whom are full-time and two part-time. All faculty spend about seventy percent of their time teaching and thirty percent in research. Funding for research is porvided by the Energy Research and Development Administration, the Bureau of Radiological Health, and the Civil Defense Agency.

Currently, there are forty-five undergraduates, all full-time, enrolled in the program. In addition, there are six full-time and six part-time graduate students enrolled. Approximately ninety percent of the students are from Massachusetts although students from the surrounding states of Connecticut, Maine, New Hampshire, Rhode Island, and Vermont are permitted to enroll in this program at the lower in-state tuition rate. This is offered because of the uniqueness of the program in New England. Recruitment of students is done only at the undergraduate level and is primarily through contact with high school science teachers. Most graduate students receive financial assistance, generally from teaching and research assistantships.

Approximately thirteen students in the B.S. program and two students in the M.S. program graduate each year. These numbers have remained constant. Of all graduates, about twenty-five percent continue their education, while a majority of the remainder find positions with government agencies and private industry. Program administrators are active in the placement of graduates by sending their resumes to potential employers. The university placement service also assists in placing graduates.

PROGRAM PROJECTIONS

The University is in the process of merging the Radiological Sciences Department with the Physics Department. The result of this will be a planned phase-out of the M.S. program along with an increase in the B.S. program. The Master's program is already being de-emphasized and no more recruiting is being done for it.

Officials anticipate an increase of three faculty members in 1978, resulting from the merger with the Physics Department. They also estimate that undergraduate enrollment will reach twenty to twenty-five students and remain stable at that level.

ADDITIONAL INFORMATION

Program officials conduct an annual one week workshop for high school science teachers in the summer. About thirty teachers attend the workshops on the benefits and risks of nuclear power each year. Training courses are conducted for the Civil Defense Agency each year and short-courses are offered in basic radiological health for persons employed in government and industry.

COURSE DESCRIPTION

(the following is a partial listing of courses)

Undergraduate courses

98-101 Introduction to Radiological Sciences - Introduction to atomic and nuclear physics; natural and artificial radio-activity radiation, decay schemes; nuclear reactions including fission and fusion; interaction of radiation with matter; radiation quantities and units; shielding; biological effects of radiation; radiation protection standards and regulations. (1 s.h.)

98-102 Introduction to Radiological Sciences - Principles of radiation detection and detection devices; radiation safety and control; and other topics. (1 s.h.)

98-401 Principles of Radiation Safety and Control - Introduction to radiation protection, including radiation sources, radiation dose and dose measurement, radiation exposure, radiation protection techniques, monitoring methods and instruments, contamination control and waste storage, facility design, hazards analysis, and applied health physics techniques for the safe handling and control of radioactive material. (3 s.h.)

98-402 Principles of Radiation Safety and Control - A laboratory course giving students experience with equipment and practices of current use in the radiation protection field, an extension of 98-401 giving some of the practical aspects of radiation safety and control. (3 s.h.)

98-403 Numerical Laboratory in Radiation Safety & Control - Extensive problem solving with examples applicable to practical aspects of radiation safety and control. Use will be made of electronic calculators and/or computers in problem solutions. (1 s.h.)

98-422 Environmental Radiation and Nuclear Site Criteria - Sources of radioactive waste and waste treatment; internal dosimetry, maximum permissible concentrations; distribution of radioactivity in the environment and the significance of releases to the air, aquatic and terrestrial eco-systems; design and operation of environmental surveillance programs around nuclear facilities; and other topics. (3 s.h.)

80-201 Physics of Radiation - Relativisitc kinematics, the photon, Compton effect, masses and charges of ions, atomic structure, X-rays, matter waves, uncertainty principle. (3 s.h.)

81-462 Radiation Biology - A study of the interactions of radiations with living systems. The effects of ionizing radiation at the molecular, cellular and organismic levels. (3 s.h.)

84-482 Environmental and Analytical Radiochemistry - A continuation of 84-481 with emphasis on some analytical and environmental aspects of radiochemistry. Laboratory experiments are performed in neutron activation, isotope dilution, and substoichiometric analyses. (2 s.h.)

Graduate courses:

98-502 Radiation Physics and Shielding Design - Interaction of neutrons, gamma rays and charged particles with matter; buildup factors; shielding design factors in reactor and accelerator operation. (3 s.h.)

98-505 Radiation Dosimetry - Sources of radiation exposure, calculations of chronic and acute radiation doses and their effects; internal dosimetry including distribution and elimination of radioisotopes; alpha, beta, gamma, and neutron dosimetry; principles of charge measurement and energy transfer; use and calibration of instruments including solid state dosimeters, ion chambers, and extrapolation chambers. (3 s.h.)

98-508 Environmental Toxicology and Epidemiology - Study of the systems of the body with respect to the sites and modes of action by various toxic agents. Current topics are included. (3 s.h.)

98-510 Environmental Toxicology Laboratory - Laboratory experiments on the effects of toxic agents on plant and animal systems with emphasis on radiation and air pollutants. (1 s.h.)

INSTITUTION: UNIVERSITY OF MARYLAND

PROGRAM: Nuclear Engineering

DEPARTMENT: Chemical Engineering

DEGREE: Master of Science (M.S.)

CONTACT:
Professor Frank Munno
Department of Chemical Engineering
Nuclear Engineering Program
University of Maryland - College Park
College Park, Maryland 20742
(301) 454-0100

PROGRAM DESCRIPTION:

PROGRAM STRUCTURE

The primary objective of the Nuclear Engineering program is the maintenance and extension of the ever-increasing degree of engineering sophistication. The program prepares the student for engineering leadership, stressing individuality and originality in each student's program. Its focus is energy conversion and power engineering with the additional specialty in radiation and polymer science. Other general areas of concentration include nuclear fuel management, transport theory, activation analysis, reactor thermal/hydraulics, reactor dynamics, radiation shielding and nuclear core design, among others.

Special facilities include the nuclear reactor, gamma and electron radiation equipment, neutron generator, and various analyzers and detectors. Extensive laboratories and two Univac computers are also available to the students.

PROGRAM REQUIREMENTS

The Nuclear Engineering Program is open to qualified students holding the B.S. degree in any engineering and science area, from accredited programs. Any student lacking required courses must compensate for these deficiencies before entering the program.

Candidates for the M.S. degree enter either the thesis or non-thesis program. A minimum of thirty semester hours is required of students in this program: twelve hours of course work in their major subject and twelve hours of course work in higher level courses, plus a thesis; or thirty hours of course work. All requirements must be met within a five-year period, and each student must have at least a 'B' average.

Financial assistance is available through research and training assistantships and traineeships.

CURRENT FACULTY, STUDENTS, GRADUATES

There are currently five full-time and one part-time faculty members, all doing research work and teaching. All members are on Maryland state budget lines. Research funding comes from NRC, IVIC (Scientific Institute), and Argonne National Laboratory.

Enrollment in the program numbers twenty-five. Students are recruited by word of mouth and packets are sent out. The program tends to attract "career change" students, though it is necessary to have an engineering or science background, or have taken appropriate courses.

Approximately five to eight students graduate each year. Through personal contact, the department finds that 25 percent of these graduates go on to further schooling, and the remaining 75 percent are employed either privately or governmentally in their field of study. The department finds the most effective means of finding employment for the graduates is through personal efforts of the students and referrals from departmental members.

PROGRAM PROJECTIONS

The program is currently developing an internship program, placing students in jobs for the summer and continuing through the academic year. Expanded computing facilities are also planned to be acquired in the future.

COURSE DESCRIPTION (SELECTED)

ENNU 430 Radioisotope Power Sources - Principles and theory of radioisotope power sources. Design and use of nuclear batteries and small energy conversion devices. (3 s.h.)

ENNU 440 Nuclear Technology Laboratory - Techniques of detecting and making measurements of nuclear or high energy radiation. Radiation safety experiments. Both a sub-critical reactor and the swimming pool critical reactor are sources of radiation. (3 s.h.)

ENNU 450 Nuclear Reactor Engineering I - Steady-state and time-dependent neutron distributions in space and energy. Conduction and convective heat transfer in nuclear reactor systems. (3 s.h.)

ENNU 470 Introduction to Controlled Fusion - The principles and the current status of research to achieve controlled thermonuclear power production. Properties of ionized cases relating to confinement and heating. Concepts of practical fusion devices. (3 s.h.)

ENNU 620 Methods of Engineering Analysis - Application of selected mathematical techniques to the analysis and solution of engineering problems; included are the applications of matrices, vectors, tensors, differential equations, integral transforms, and probability methods to such problems as unsteady heat transfer, transient phenomena in mass transfer operations, stagewise processes, chemical reactors, process control, and nuclear reactor physics. (3 s.h.)

ENNU 649 Selected Topics in Nuclear Engineering - Topics of current interest and recent advances in the nuclear engineering field. Because of the rapid advances in the field, information on special topics of much practical importance is continually becoming available. (2 s.h.)

ENNU 656 Radiation Engineering - An analysis of such radiation applications as synthesizing chemicals, preserving foods, control of industrial processes, design of irradiation installations. (3 s.h.)

ENNU 730 Radiation Shielding and Energy Deposition - A study of the interactions of nuclear radiations with matter. Includes electron, gamma and neutron attenuation, dose calculations, chemical changes, heat generation and removal in shields. (3 s.h.)

ENNU 761 Nuclear Fuel and Waste Processing - Processing of nuclear fuel and treatment of nuclear waste. (3 s.h.)

ENNU 840 Nuclear Reactor Design - The design features of nuclear reactor systems. The preliminary design of a reactor is carried out by the student. Core design including heat transfer, control system, safety systems and shielding. Standard computer programs are utilized throughout. (3 s.h.)

INSTITUTION: UNIVERSITY OF MICHIGAN

PROGRAM: Radiological Health

DEPARTMENT: Environmental and Industrial Health

DEGREE: Master of Public Health (M.P.H.)
Master of Science in Environmental Health Sciences (M.S.)
Doctor of Public Health in Environmental Health Sciences (Dr.P.H.)
Doctor of Philosopy in Environmental and Industrial Health Sciences (Ph.D.)

CONTACT: Dr. G. Hoyt Whipple
Division of Radiological Health
Department of Environmental and Industrial Health
School of Public Health
University of Michigan
(313) 764-0523

PROGRAM DESCRIPTION:

PROGRAM STRUCTURE

Instituted in 1957, the Radiological Health program at the University of Michigan, emphasizes "investigation of problems with practical implications." As a recent departmental grant proposal notes, ". . . training is not limited to narrow specialization in radiation. Considerable effort is made to acquaint the student with hazards to life and health other than radiation. The Department competencies in industrial hygiene, toxicology, occupational health and in air and water pollution are important factors in this effort." The specific thrust of the radiological health field involves "the measurement, evaluation, and control of the radiation to which humans are exposed in the environment and in the work place."

Five programs in Radiological Health are offered:

(1) special student--two terms of graduate study which do not lead to a degree
(2) M.S.--five terms of graduate study for the person interested in applying scientific skills to solve problems in radiological health
(3) M.P.H.--normally five terms of graduate study for the person who desires broad training in public health with a specialization in radiological health
(4) Dr.P.H.--six-ten terms of graduate study for the person interested in applied professional practice and administration rather than in research and teaching
(5) Ph.D.--six-ten terms of graduate study beyond the master's level for the person interested in research and teaching.

The resources available to students enrolled in the Radiological Health program are many and varied. Faculty members are specialists in the field with backgrounds in engineering, mathematics, physics, ecology, biology, and chemistry. Facilities include a high-level radioactivity laboratory, low-level radioactivity laboratory, X-ray laboratories, radioactivity counting laboratory, and instrumentation in radioactivity and radiation measuring. Specialized equipment includes two gamma spectrometers; a low background anticoincidence counter; a life-size, tissue-equivalent phantom man; an instrumentation calibration facility; and a liquid scintillation facility. There are laboratory facilities for animal and bacteriological studies, a nuclear reactor with an adjacent greenhouse, and a high-level radiation source in the Phoenix Memorial Laboratory. The program is coordinated with teaching and research in other schools and departments, including nuclear engineering, medicine, industrial health, zoology, and meteorology and oceanography. Students may participate in studies of levels of environmental radioactivity and of the standardization of measurement methods being conducted by the National Sanitation Foundation. Extensive field work opportunities are available through the Radiation Control Service which supervises all University medical units, research activities and laboratories, including the nuclear reactor, with respect to exposure to University personnel, disposition of radioactive wastes, methods of handling, and persons permitted to handle radioactive materials. The School of Public Health Library is a depository for all publications of the U.S. Public Health Service. Two of the radiological health labs are equipped with remote terminals from the university's IBM 360 computer.

Current research projects involve the radiation resistence and mortality rates of various species of gerbils; the analysis of the fate of radioiodine in patients discharged after diagnosis and therapy and the transfer of radioiodine from patient to family members; Nuclear Regulatory Commission-funded evaluation of the feasibility of a mandatory personal dosimeter testing program; and the measurement of carbon-14 released into the environment in gaseous and liquid form, determination of what fractions of the carbon-14 released to the atmosphere are in the oxidized and in the reduced states, development of suitable methods for monitoring carbon-14 in gaseous and liquid effluents routinely, and investigation of the sources of carbon-14 within the nuclear power plant with a view to establishing a materials balance between production and emission; and the design, construction, and operation of a batter-powered, high-volume air sampling device to monitor particulate radioactive materials and radioiodine in the environment (utility company funding).

The Radiological Health program sponsors a two-week short course in radiation protection annually for personnel in industry and government. The Applied Radiation Control course (EIH 697) is designed to permit students to use the theoretical principles in radiological health in making practical judgments; activities included in this course are revised annually but have involved auditing at the nuclear reactor, evaluation of radiation data from three plants, and drafting of an environmental impact statement.

PROGRAM REQUIREMENTS

Admission to any of the five programs in Radiological Health requires a bachelor's degree in science or engineering, the Graduate Record Examination (GRE), and college courses in mathematics, physics, biology (recommended), and chemistry (recommended). All applicants whose native language is not English are required to take an English proficiency exam before they may be accepted for admission. An applicant for the Master of Public Health program should possess a graduate degree from an acceptable institution in a discipline related to public health or a bachelor's degree from an acceptable institution with substantial knowledge in a discipline relevant to public health either through study or experience or a combination of these. An applicant for the Doctor of Public Health degree must possess the M.P.H. degree or its equivalent and must have demonstrated evidence of the capacity to undertake the work for a doctoral degree.

The special student's non-degree program is developed individually in view of the student's previous education, experience, needs, and interests. The M.S. program requires a minimum of thirty-six semester credits and most programs require five terms of study. The M.P.H. program with specialization in radiological health includes a core requirement providing a basic body of information, certain unique techniques and skills, and appropriate values, orientations, and attitudes, in accordance with the accreditation criteria of the American Public Health Association. Both master's degree programs include coursework in radiation dosimetry, radiation biology, statistics, practical experience (internship or field work), environmental surveys, and practical radiation control. Students are encouraged to take courses in industrial hygiene, toxicology, and epidemiology to broaden their training and their utility for prospective employers. There is no thesis requirement for the master's degrees; but in practice, about one-half of the students elect to conduct a research project and submit a written report. The Ph.D. is the traditional advanced degree in scientific research; and coursework is built around the student's doctoral dissertation problem, which generally involves laboratory or field research. The Doctor of Public Health is a degree in advanced professional practice; the plan of study includes a series of advanced courses related to radiation protection and several projects involving analysis, evaluation, and judgment, but not necessarily laboratory work, of the kind the graduate will be expected to undertake in his/her professional life.

CURRENT FACULTY, STUDENTS, GRADUATES

Four faculty members serve eleven students in the Radiological Health programs. The limited financial support available to these graduate students and the high tuition costs at the University of Michigan are of great concern to the departmental faculty as contributing factors to a decline in enrollment and a reduced capacity to attract qualified applicants. Currently, one M.S. student and one Ph.D. student are supported by research funding from Consumers Power Company and as such, are obligated to work on specific research projects of interest to the nuclear industry; the remaining students work part-time or have some form of loan support.

In the twenty years since its inception, the Radiological Health program has awarded 73 M.P.H., 104 M.S., 31 Ph.D., and 2 Dr.P.H. degrees to 185 students. In the last three years, 1 M.P.H., 26 M.S., and 1 Ph.D. diplomas have been conferred. Generally, every qualified graduate has been able to choose among several appropriate positions upon graduation. Currently, there is a 5:1 ratio of jobs to graduates. The practical nature of the program facilitates entry of the students in large numbers into industrial jobs. Another large number have taken positions with state and federal agencies while the remainder have gone into work in hospitals, consulting firms, research laboratories, and universities.

PROGRAM PROJECTIONS

The recruitment of and the financial support for qualified graduate students are the critical variables in the continued existence of the Radiological Health program at the University of Michigan. Without these elements, the program will probably decline. The increasing emphasis placed on nuclear power as a source of energy and the availability of well-paying jobs for program graduates bespeak the need for such a program now and in the future. According to a recent program review, plans exist to "add or modify courses in the last two terms so that the needs of people going into medical health physics will be served better than at present."

COURSE DESCRIPTION

Environmental and Industrial Health:

501 Environmental Physiology - The effect of environmental stresses on human physiology. Mechanism of production of disease through toxic materials in air, in food, and in water. Physical variants of temperature, air pressure, electromagnetic energy, and vibration in the production of disease states. (2 s.h.)

502 Principles of Environmental Health - Principles of engineering and science used in the control of man's environment. Includes water supply and treatment, sewerage, wastewater treatment, plumbing and cross connections, swimming pools and bathing areas, refuse collection and disposal, industrial hygiene, ventilation, noise, illumination, community air pollution, radiological health principles, food and milk sanitation, insect and rodent control, housing. (3 s.h.)

533 Fundamentals of Instrumental Methods of Chemical Analysis - Fundamental principles, operation, and application of modern instruments in scientific analysis. Instruments include emission, ultraviolet and infrared spectroscopy, X-ray emission and diffraction, gas chromatography, mass spectroscopy, and others. Emphasis on application to environmental and medical fields. (3 s.h.)

634 Instrumental Methods of Chemical Analysis - Extensive laboratory practice in use of instrumental methods of analysis on selected analytical problems. Instruments include emission, ultraviolet,

634 (cont'd) - visible and infrared spectroscopy, X-ray emission and diffraction, gas chromatography, electrometric measurements, and others. (3 s.h.)

692 Radiological Health Seminar - Special topics of importance in the control of radiation hazards. For students and workers in radiological health, nuclear science, and nuclear engineering. (1 s.h.)

693 Radiation Physics - Atomic, nuclear, and radiation physics as related to radiological health and radiation dosimetry. Emphasis on quantitative mastery of production, transmission, and absorption of ionizing radiations, including X- and gamma-radiation, alpha and beta particles, and neutrons. (3-4 s.h.)

694 Radiation Dosimetry - Principles and methods of protection against radiation hazards, with emphasis on occupational and other environmental aspects. Dosimetry, personnel protection, instruments, and special health physics techniques and problems. (3-4 s.h.)

695 Radiation Biology - Integration of current knowledge about radiation effects on mammals, its application in quantitative evaluation of relations between characteristics of various radiation exposures and of somatic and genetic effect in man and animals. Radiation protective and therapeutic measures. (3-4 s.h.)

696 Sources and Control of Radioactive Waste - Evaluation of the significance of uses of nuclear energy in relation to environmental processes and possible methods for control of radioactive wastes. Consideration of biological accumulation and movement of radioisotopes in the environment. Collection and preparation of samples, quantitative and qualitative identification of radioisotopes, statistical accuracy, and experiments on biological accumulation of radioactivity. (3 s.h.)

697 Applied Radiation Control - Application of principles of radiological safety in design and operation of facilities using radiation and radioactive materials. Examples of existing facilities. Student design of installations, specifications of necessary radiation instruments, and appropriate operating procedures. (2 s.h.)

702 Field Experience - Investigation and practical experience in industrial health, air and water pollution, radiological health, or other specific environmental health problems. (2-6 s.h.)

Nuclear Engineering:

400 Elements of Nuclear Energy - A survey of applications of nuclear energy for those in the fields other than nuclear engineering. History of the nuclear energy program, elementary nuclear physics, nuclear fission and fusion reactors, radiological health physics and nuclear medicine, nuclear power generation, nuclear weapons development and control. (3 s.h.)

512 Interaction of Radiation and Matter - Classical and quantum-mechanical analysis of the processes by which radiation interacts with matter. Review of nuclear structure and properties. Nuclear models. Nuclei as sources of radiation. Interaction of electromagnetic radiation with matter. Interaction of charged particles with matter. Radiative collisions and theory of bremsstrahlung. Interaction of neutrons with matter. Interaction mechanisms and cross sections are developed. (3 s.h.)

554 Radiation Shielding - A macroscopic study of the absorption of nuclear radiation in dense materials with applications to radiation shielding. Topics considered include radiation sources, permissible radiation levels, gamma-ray attenuation, neutron attenuation, shield optimization, heat generation and removal in shields, and other problems. (3 s.h.)

INSTITUTION: UNIVERSITY OF NORTH CAROLINA AT CHAPEL HILL

PROGRAM: Radiological Hygiene

DEPARTMENT: Environmental Sciences and Engineering

DEGREE: Master of Science (M.S.)
Master of Science in Public Health (M.S.P.H.)
Doctor of Philosophy (Ph.D.)

CONTACT: Dr. Russell F. Christman, Professor and Chairman
Department of Environmental Sciences and Engineering
School of Public Health
The University of North Carolina
Chapel Hill, North Carolina 27514
(919) 966-1171

PROGRAM DESCRIPTION:

PROGRAM STRUCTURE

The Department of Environmental Sciences and Engineering is a component of the School of Public Health of the University of North Carolina at Chapel Hill. The school is one of five professional schools in the university's Division of Health Sciences, and is one of nineteen such schools in the U.S. accredited by the Council on Education for Public Health. Graduate study and research in sanitary engineering were initiated in 1921. The program continually expanded and became Environmental Sciences and Engineering in 1962. In addition to Radiological Hygiene, the department offers graduate instruction and research in four other programmatic areas: Air and Industrial Hygiene, Environmental Chemistry and Biology, Environmental Management and Protection, and Water Resources Engineering.

The Radiological Hygiene program deals with the applications and assessment of radiation in the total human environment. Students may emphasize health physics, which is a discipline devoted to the protection of humans and their environment from unwarranted radiation exposure. An emphasis in medical physics may also be pursued, which is concerned with the uses of radiation in the diagnosis and treatment of human diseases. The Radiological Hygiene program offers the M.S., M.S.P.H. and Ph.D. degrees. Students emphasizing health physics are prepared for careers in industry or with governmental agencies. These graduates participate in the planning and execution of programs in occupational and environmental radiation protection. Medical physics graduates, through research, clinical consultation and services, and teaching, contribute their expertise in hospitals and research facilities. Study for the Ph.D. is intended primarily for those preparing for careers in teaching and research, although the degree is becoming increasingly applicable for professional practice.

The department places heavy emphasis on research, and is involved with over seventy separate research and grant contracts in diverse environmental fields. The Radiological Hygiene program's present research interests include computer and scale modeling of radioactive effluents, environmental monitoring, instrumentation development, ultrasound research including tissue characterization and dosimetry, and microwave dosimetry. The radiological laboratory is equipped with a full complement of radiation detection instrumentation. This includes automated liquid scintillation counters and proportional counters, a variety of sodium iodide scintillators, and hyperpure germanium high-resolution spectrometer. A Harsaw thermoluminescent dosimetry system is available, as well as a microcomputer and a wide variety of counting equipment. Additionally, the use of facilities such as electron microscopes, gas chromatographs and spectrophotometers which belong to other program areas, is possible.

Students have access to the above facilities, which provide a wide range of research activities in health physics and medical physics. Student projects may range from basic laboratory research to field studies, and cooperative research efforts are available with the North Carolina Memorial Hospital and with federal laboratories in the vicinity such as those of the U.S. Environmental Protection Agency (EPA) and the National Institute of Environmental Health Sciences. Some students have performed research during the summer with the U.S. Bureau of Radiological Health.

The department is the primary recipient of a long-term National Institute of Occupational Health Studies (NIOSH) grant for the purpose of training personnel needed to implement the Occupational Safety and Health Act. The grant has established the Occupational Safety and Health Resource Center, which is a focus for educational activities and a stimulant to multidisciplinary research in occupational safety and health.

Under contracts with the Agency for International Development (AID) the department has carried out programs of assistance and research for developing countries on the environmental impact of development. Past programs were carried out with universities in Peru and Guatemala, and with representatives of thirty-five other countries throughout the world. The department currently conducts short courses for AID and the U.N. Industrial Development Organization for personnel from developing countries in Central America and Africa.

PROGRAM REQUIREMENTS

For admission into the department, all candidates must submit at least two letters of academic reference, a statement of career objectives, the aptitude portion of the Graduate Record Examinations, and transcripts from all institutions attended (the average grade point for new students in the Radiological Hygiene program in the fall of 1977 was 3.45, the average GRE score 950). For doctoral students, a statement of research interests is also required.

Undergraduate training in physics or nuclear engineering provides the strongest background for master's level radiological hygiene studies. Students with bachelor's degrees in biology, chemistry, engineering, or other sciences are also candidates for the program, but would be expected to take appropriate courses to correct their deficiencies in atomic and nuclear physics. All students are expected to have a year of college physics and a year of college math through calculus. Entrance into the Ph.D. program normally requires a previous master's degree in health physics, medical physics, physics, nuclear engineering, or a related field. Admission also requires the sponsorship by a faculty member who agrees to serve as the student's program advisor.

The department requires that M.S.P.H. candidates take a basic biostatistics course, a basic epidemiology course, and five departmental courses (or fifteen hours) in a field consistent with the program area. To meet radiological hygiene requirements, all master's students must satisfy a set of core requirements. The balance of the courses of study are individually designed in consultation with faculty advisors to meet professional objectives. A minimum of thirty semester hours of credit is required for all master's degrees, and all M.S.P.H. candidates must submit a technical report based on a comprehensive literature survey, an internship-like involvement with professionals, or conventional research. M.S. candidates must prepare and defend a thesis at the conclusion of an independent research project. Technical reports and theses are presented at the time of the required oral comprehensive examination.

There are no formal course requirements for the Ph.D.; a program of study is developed with the student's committee to provide mastery in the chosen field. In addition to the major, doctoral candidates must have a supporting program of at least fifteen hours; a formal minor may be elected. Two courses in a research skill are required, and all course work is examined at the time of a written examination. An approved dissertation must be prepared that is expected to be a significant and original contribution to knowledge. This is presented and defended at a final oral examination. Registration in ENVR 394 for at least three credit hours is required in the completion of the dissertation.

CURRENT FACULTY, STUDENTS, GRADUATES

Two full-time and five supporting faculty members carry out teaching and research responsibilities within the Radiological Hygiene program. The supporting faculty includes three medical physicists of the UNC School of Medicine, the director of the UNC Occupational Health and Safety Office, and a person holding a joint appointment as professor of physics at North Carolina State University and as professor of radiological sciences at UNC. All faculty members hold the doctorate degree, with backgrounds and major research/teaching interests in a variety of areas within radiological hygiene.

During the 1977-1978 term, nine persons are seeking master's degrees in the Radiological Hygiene program, as well as two persons seeking the Ph.D. These enrollments represent an increase over the last three to five years. Six of these students are self-supporting; the remainder are supported by training grants and assistantships. The number of training grants available to students in the department has substantially reduced in recent years.

Two persons graduated with the M.S.P.H. degree during the 1976-1977 term. One joined the E.I. duPont deNemours nuclear facility and the other joined the Savannah River Laboratory, both located at Aiken, South Carolina. During 1976-1977, two received the M.S.P.H. and one the M.S. The latter became employed with the Tennessee Valley Authority. One of the M.S.P.H. graduates became a medical physicist in a hospital, and the other is pursuing the doctorate degree at UNC. Other organizations with which program graduates are employed include EPA, the Department of Energy, the states of Kentucky, Illinois and North Carolina, General Electric Company, Westinghouse Corporation, and a number of hospitals and universities.

PROGRAM PROJECTIONS

The student enrollment in the department and within the specific programs is not expected to increase, as the department is currently authorized to admit only as many students as it graduates. A major departmental programmatic change, however, may take place within the year. Under discussion is the development of research and course offerings on the effects of contaminants on human health. As envisioned, such a development would embrace such diverse disciplines as toxicology, medicine, pharmacology, and oncology, and would tackle such questions as the relationship of water quality to cancer incidence and the effects of air discharges on upper respiratory ailments. How this new emphasis will be incorporated into the current departmental structure is as yet undecided. A research committee has been developed to study the alternatives and provide recommendations; monies are available for several new faculty members; and efforts are under way to secure new research grants in this area.

COURSE DESCRIPTION

Required courses:

ENVR 162 Modern Physics for Environmental Science - Modern physics with emphasis on radioactivity and ionizing radiations. (3 s.h.)

ENVR 163 Radiation Instrumentation - Laboratory study of measurements of radioactivity with emphasis on principles of operation of the instruments. (3 s.h.)

ENVR 261 Radiation Biophysics - The biophysical factors of radiation quality and the response of cell populations. Current

ENVR 261 (Cont'd) - models of the mechanisms of radiation action on biological systems. Microdosimetry and dosimetry at interfaces. (3 s.h.)

ENVR 263 Radiation Hazards Evaluation - Principles and techniques of external and internal radiation hazards evaluation. Interaction of radiation with matter and fundamentals of radiation dosimetry. (3 s.h.)

ENVR 360 Research in Radiological Hygiene - Execution of independent investigation and preparation of a paper. (3 or more s.h.)

GN 532 Biological Effects of Radiation - (offered at North Carolina State University)

An approved course in environmental sciences, exclusive of radiological hygiene (not required for the M.S. degree)

Selected approved Environmental Sciences and Engineering electives:

ENVR 111 Environmental Policy Analysis - Issues in environmental protection. Analysis of environmental problems and decisions from viewpoints of various disciplines concerned with the assessment of risk, policy development and environmental management. (3 s.h.)

ENVR 112 Energy and Man's Environment - Development of U.S. energy resources and present and future energy conversion technologies from the standpoint of their impact on human health and the environment. (2 s.h.)

ENVR 141 Elements of Air Hygiene - Health aspects of the air from standpoint of community air pollution. Chemical and physical behavior and biological effects of air contaminants. Means of controlling air pollution. (2 s.h.)

ENVR 142 Elements of Industrial Hygiene - Problems and control of exposure to occupational diseases and industrial accident hazards, the organizations and function of industrial and governmental services dealing with these problems, the industrial aspects of communicable and noncommunicable diseases, the procedures of workmen's compensation plans, and the integration of occupational health services with local health department activities. (2 s.h.)

ENVR 143 Applied Physiology and Toxicology - Physiologic response of various organs and organ systems of the body to the chemical and physical stresses of the industrial environment. Methods of industrial toxicology and toxicological basis for the Threshold Limit Values. Concentration-Time equivalence, routes of entry, synergism. (3 s.h.)

ENVR 147 Occupational Safety - Fundamentals of occupational safety with emphasis on legislation and organization of industrial safety programs including hazard recognition, analysis, control and motivational factors pertaining to industrial accident prevention. (2 s.h.)

ENVR 154 Management of the Institutional Environment - Study of the particular environment of hospitals, nursing homes, schools, and related institutions. Application of biological and chemical methods to identification of problems; the epidemiology and management of environmental factors influencing health in the institutional setting. (3 s.h.)

ENVR 164 Field Observations in Radiological Hygiene - Field observations of modern public health practice in state and local agencies and of health physics practice at the Oak Ridge National Laboratory and associated facilities. (3 s.h.)

ENVR 171 Water Quality Evaluation and Control - Characteristics of water as a resource. Water uses, trends. Water quality concepts, measurements, criteria, problems, pollutants. Water supply and wastewater treatment and disposal systems. Regulation of water quality standards. (3 s.h.)

ENVR 212 Planning and Development of Environmental Hygiene Programs - Concepts and techniques in planning, organization and management. Program development, decision making, methods for achieving administrative ends, field supervision, criteria establishment and evaluation procedures with reference to environmental hygiene programs. (3 s.h.)

ENVR 215 Environmental Issues and Assessment - Concepts and methodologies for assessing the environmental, ecological, and social consequences of technological development. Preparation of environmental impact statements, and case studies of specific projects. (2 s.h.)

Other approved electives:

AADM 105	Concepts of Health Administration
BIOS 108	Introduction to Statistical Data Processing
BIOS 109	Computer Programming in Biostatistics
BIOS 145	Principles of Environmental Management
BMME 101	Introduction to Biomedical Engineering
BMME 111	Biomedical Instrumentation
BMME 121	Introduction to Biomedical Data Processing
COMP 114X	Systematic Programming
COMP 216X	Introduction to Computer Use
COMP 254	Picture Processing and Pattern Recognition
PHYT 102	Mammalian Structure and Function

INSTITUTION: UNIVERSITY OF PITTSBURGH

PROGRAM: Radiation Health

DEPARTMENT: Radiation Health

DEGREE: Master of Science in Hygiene (M.S.)
Doctor of Science in Hygiene (D.S. Hyg.)
Doctor of Philosophy (Ph.D.)
Doctor of Public Health (in various subspecialty areas) (DPH.)

CONTACT:

Dr. Gerald St. Denis	Dr. Joseph A. Watson
Asst. Dean for Student	Professor of Radiobiology
and Alumni Affairs	Dept. of Radiation Health

Graduate School of Public Health
University of Pittsburgh
Pittsburgh, Pennsylvania 15260
(412) 624-3002

PROGRAM DESCRIPTION:

PROGRAM STRUCTURE

The Graduate School of Public Health's Department of Radiation Health provides training, research and services in several interrelated subspecialty areas: radiobiology; health physics; radiation chemistry; environmental radiation; radiation medicine; radiological physics and radiological engineering. General training in radiation health with emphasis on one of the subspecialty areas is offered to students enrolled in the department. In addition, subspecialty training in cytogenetics is available in collaboration with the human genetics program of the Department of Biostatistics. Although the major emphasis of the program is to prepare radiation protection practitioners through the M.S. (Hygiene) degree program, some doctoral programs are also available in the various subspecialty areas.

The department's main objective is to provide properly trained professional graduates to function as operating personnel, teachers, and research investigators in the recognition, prevention and management of health problems associated with ionizing and non-ionizing radiation. Research is conducted on the recognition and reduction of radiation hazards and on the development of methods and services to detect and minimize harmful radiation effects on health.

The department utilizes a three-story Radiation Center jointly with the Department of Radiology at the School of Medicine. The Radiation Medicine Department also contains low-level, whole-body radiation county facility and a clinical cytogenetics laboratory. An active research program is conducted in all of the subspecialty areas with investigators in other programs, including occupational health, environmental health, human genetics, radiology, and electrical engineering.

PROGRAM REQUIREMENTS

In order to be admitted to the Graduate School of Public Health, a quality point average of 2.5 out of a possible 4.0 in undergraduate work is required for admission to any master's program. Candidates for admission for the M.S. (in Hygiene) degree must hold a B.S. or A.B. degree in arts, science, engineering or nursing, or an M.D., D.D.S., or D.V.M. from an approved school. Prospective candidates must present evidence of having had adequate training in the sciences basic to public health and may be required to take any examinations the faculty considers necessary in order to judge the student for admission.

Candidates for the M.S. (Hygiene) degree in radiation health must complete a plan of study which includes: two courses in basic areas of public health (Bios 241 and Epid 211); Rad.H. 210 and a minimum of three credits of Rad.H. 219; participation in Rad.H. 225; a minimum of fifteen credits of specialized radiation health courses; and a research report or essay covering an independent investigation on a topic directly related to radiation health.

Students have opportunities to participate in the Radiation Protection Assistance Program conducted by the Department for Regional Industry as part of their academic training. Employment opportunities are also provided by the university's Radiation Safety Office which collaborates closely with the Department in providing radiation protection services.

The Graduate School of Public Health has a limited amount of general purpose traineeship funds which are distributed among the various departments. The Department of Radiation Health supports fifteen traineeships which provides $500 in tuition funds for students.

CURRENT FACULTY, STUDENTS, GRADUATES

Twenty faculty members contribute to the offering of the department's curriculum. Of this total, three are full professors, one is a research associate professor, three are research assistant professors, one is a clinical professor, one is an associate professor, and three are assistant professors. In addition, the University Health Physicist serves as a health physics instructor, and services are provided by seven adjunct professors.

There are currently (Spring, 1978) a total of thirty-four students enrolled in the Department of Radiation Health. Of this total, fifteen are full-time and nineteen are part-time students. During 1977, a total of ten students received advanced degrees and all except one (Doctor of Science) received their M.S. (Hygiene) degree in radiation health.

Most graduates find positions with governmental agencies (including health departments), hospitals, or in academia. Graduates serve as operating personnel, teachers or research professors.

PROGRAM PROJECTIONS

No expansion in either staff or enrollment is expected in the Department of Radiation Health in the next few years. Because of inadequate laboratory space, the department is unable to accommodate additional students. Budgetary constraints will not allow more than fifteen new first year students to be admitted into the programs at one time.

COURSE DESCRIPTION (SELECTED)

Rad H 210 Introduction to Radiation Health - This lecture course offers a perspective for integrating didactic instruction in the areas of knowledge fundamental to radiation health and providing familiarization with career opportunities in the field. (1 s.h.)

Rad H 219 Radiation Health Practice - Professional practice in radiation protection via cooperative work assignments with industry, hospitals, governmental agencies, research laboratories, etc. (1-3 s.h.)

Rad H 222 Radiation Effects on Materials - Effects of radiation on aqueous solutions and organic compounds; corrosion and degradation products; polymerization, pasteurization and sterilization; fatigue of structural materials. (1 s.h.)

Rad H 230 Survey of Radiation Health - A descriptive, nonmathematical overview of the physical characteristics of ionizing radiations, their biological effects, and the methods by which protection of radiation workers and the general public is achieved. (1 s.h.)

Rad H 233 Radiobiology II - Radiation-induced alterations in physiology of various mammalian organs and systems are examined including immediate and long-term responses of living mammalian organisms, and of man in particular. (2 s.h.)

Rad H 241 Diagnostic Radiological Physics - Radiology practices; nuclear medicine practices, contamination control and waste disposal; clinical demonstrations. (1 s.h.)

Rad H 250 Reactor Hazard Evaluation - Structure, operation, and control of various types of nuclear reactors are presented, emphasizing safety aspects. (1 s.h.)

Rad H 252 Environmental Radiation - Natural radioactivity, sources and relative dose contributions, methods of evaluation, technologically enhanced exposures to natural radiation; other topics of interest. (2 s.h.)

Rad H Radiation Risk Analysis - Radiation protection criteria are examined within the context of risks to large populations over extremely long time intervals. Risk models are compared. (1 s.h.)

Rad H 315 Radiation Measurements and Dosimetry - Advanced instrumentation and methodology for making radiation measurements and for evaluation radiation doses are presented. Laboratory efforts are devoted to the application of sophisticated techniques to radiation dosimetry problems. (3 s.h.)

Rad H 335 Advanced Topics in Radiation Health - Recent advances in research, current controversies, and issues of social and economic concern related to radiation protection are presented in this reading and lecture course. Specialized topics in radiobiology, radiation chemistry, dosimetry, radioecology radiation engineering and related areas are included. (2 s.h.)

INSTITUTION: UNIVERSITY OF TENNESSEE (UT)

PROGRAM: Nuclear Engineering
DEPARTMENT: Nuclear Engineering
DEGREE: Bachelor of Science (B.S.)

CONTACT: Dr. P. F. Pasqua, Head
Department of Nuclear Engineering
University of Tennessee
Knoxville, Tennessee 37916
(615) 974-2525

PROGRAM DESCRIPTION:

PROGRAM STRUCTURE

As a response to the rapidly increasing demand for engineers with a knowledge of nuclear phenomena, nuclear engineering became a department in 1957. Graduates of the baccalaureate program are equipped for entry into a variety of work in industry, research, or for graduate studies.

The department is housed in the Nuclear Engineering Building, which contains laboratories and equipment for monitoring, counting, and investigating various nuclear phenomena; it also contains subcritical reactors. Nuclear engineering has an arrangement with the Oak Ridge National Laboratory (ORNL) which permits students to utilize the facilities there for instruction and research. Included are the reactor facilities, the Information Centers, the libraries and depositories, and the computers. UT is a member of the Oak Ridge Associated Universities (ORAU) which provides students with additional opportunities for instruction and research.

PROGRAM REQUIREMENTS

University admissions standards require entrants to have completed an academic high school program and to submit their scores received on the ACT examination. Applicants must also have recommendations from their high school principals. In order to receive a bachelor's degree after July 1, 1978, all students must have completed one year of American history at the high school level or nine quarter hours of collegiate American history, as required by the General Assembly of the State of Tennessee. The College of Engineering further requires freshman entrants to have completed three years of English, two years of algebra, one year of geometry, and one-half year of advanced math or trigonometry. Three years of science, including physics are recommended.

The curriculum in nuclear engineering is designed to provide basic training in many of the fields encountered in the applications of nuclear and radioactive materials. The first two years are concerned with the fundamental courses in engineering, physics, mathematics, chemistry, and English. The final two years encompass scientific and engineering courses.

Nuclear engineering major requirements include the following courses: 2310-20-30 - Seminar, 3030 - Introduction to Reactor Analysis, 3040 - Environmental Effects of Nuclear Technology, 3150 - Dynamics and Controls, 3210-20 - Thermodynamics, 3730 - Momentum Transport, 4110-20-30 - Introduction to Nuclear Reactor Theory, 4210-20-30 - Nuclear Engineering Laboratory, 4710 - Energy Transport, 4720 - Reactor Thermal Design, 4730 - Nuclear Reactor Design, 4810 - Radiation Shielding, and 4820 - Reactor Kinetics and Controls. The entire program consists of the completion of one hundred and ninety-five quarter credits.

CURRENT FACULTY, STUDENTS, GRADUATES

The Department of Nuclear Engineering has nine full-time persons on its faculty, all of whom are involved in research to varying degrees.

There are one hundred and twenty-one students involved full-time in nuclear engineering, and nine part-time. An important feature of this department is its coop program. Neither seniors nor freshmen may participate in the coop, but of the remaining fifty-eight students, twenty-nine (half) have coop placements. No academic credit is received, and they must maintain a 3.0 average in their course work.

Twenty-three people are expected to graduate in the spring of 1978, and of those approximately fourteen, or 60 percent, will continue their studies in graduate school. The remainder are commonly employed by the Tennessee Valley Authority and various nuclear power plants. In years past, the Oak Ridge National Laboratory hired many of the UT graduates but it is feared that the nuclear facility may become "inbred" if graduates of other schools (and differing emphases) are not employed to a larger degree.

PROGRAM PROJECTIONS

Because of the tremendous need for new energy technologies, there are plans underway to develop an option for specialization in nuclear fusion. Also, the rightful concern over nuclear waste storage and ultimate disposal has caused this department to address that problem; a fuel management and waste disposal program is being designed.

COURSE DESCRIPTION

Required Courses:

2310-20-30 Seminar - Presentation and discussion of topics related to Nuclear Engineering. (1 q.h. each)

3030 Introduction to Reactor Analysis - Nuclear reactions and radiations, cross section, fission process, diffusion and slowing down, steady state reactor theory criticality condition, reflected reactors. (3 q.h.)

3040 Environmental Effects of Nuclear Technology - Study of effects on environment since advent of peaceful and military uses of nuclear energy. (3 q.h.)

3150 Dynamics and Controls - Systems differential equations; solution by classical methods; Laplace transform method; frequency response, stability, and control. (3 q.h.)

3210-20 Thermodynamics - Properties and laws of thermodynamic systems. First and second laws used to analyze power plant systems - both fossil fuel and fission. (4 q.h. each)

3730 Momentum Transport - Development of differential and integral momentum equations; elementary theory of turbulence, applications to piping systems, pumps and nuclear reactors. (4 q.h.)

4110-20-30 Introduction to Nuclear Reactor Theory - Nuclear structure; radioactive decay laws; neutron interaction; fission processes, chain-reacting systems; diffusion equation including multigroup diffusion theory, neutron moderation; reactivity coefficients; perturbation theory. (3 q.h. each)

4210-20-30 Nuclear Engineering Laboratory - Radiation detection and counting instrumentation, counting statistics, half-life and decay schemes, gamma spectrometry, cross-section measurements, analog computation, diffusion properties of neutrons, critical loading experiments, control rod calibration, statistical weight, shielding, xenon poisoning, prompt critical reactor behavior, fission density and adjoint flux. (3 q.h. each)

4710 Energy Transport - Development of differential and integral energy conservation equations; conduction, convection, and radiation heat transfer; application of nuclear reactor fuel elements and heat exchangers. (3 q.h.)

4720 Reactor Thermal Design - Hydrodynamics and heat transfer in boiling systems; boiling crises; fuel element thermal design, steam generator design. (3 q.h.)

4730 Nuclear Reactor Design - First order reactor design, integration with nonnuclear heat transfer and power conversion

4730 (Cont'd) - system, economic evaluation; optimization procedures, description of typical systems. (3 q.h.)

4810 Radiation Shielding - Types of radiation sources, gamma ray and neutron attenuation, biological effects of radiation, shield design. (3 q.h.)

4820 Reactor Kinetics and Controls - Derivation of kinetic equations; basic kinetics parameters; transient response with feedback; control and protective systems. (3 q.h.)

Electives:

4140 Thermonuclear Systems - Fusion reactions; properties of plasmas; plasma containment; plasma diagnostics; thermonuclear devices. (3 q.h.)

4530 Reactor Simulation Laboratory - Simulation of reactor design and operation with analog computer; reactor kinetics; single and multigroup theory, reactivity coefficients, poisoning, control rod calibration; power reactor; subcritical assembly. (3 q.h.)

4610-20-30 Reactor Power Systems - Nuclear structure, decay laws, neutron diffusion, time behavior of reactors, heat removal, analysis of reactor power plants; economic, safety, and environmental aspects of nuclear power. (3 q.h. each)

4840 Nuclear Reactor Safety - Presentation of reactor safety concepts and criteria; credible accidents; fission product release and transport; containment systems; accident analysis; engineered safeguards. (3 q.h.)

4930 Nuclear Fuel Management - Discussion of problems associated with processing of nuclear materials; fuel cycle analysis; burnup calculation. (3 q.h.)

INSTITUTION: UNIVERSITY OF TENNESSEE (UT)

PROGRAM: Nuclear Engineering

DEPARTMENT: Nuclear Engineering

DEGREE: Master of Engineering (M.E.)
Master of Science (M.S.)
Doctor of Philosophy (Ph.D.)

CONTACT: Dr. P. F. Pasqua, Head
Department of Nuclear Engineering
University of Tennessee
Knoxville, Tennessee 37916
(615) 974-2525

PROGRAM DESCRIPTION:

PROGRAM STRUCTURE

Nuclear engineering became a department in 1957 in response to the growing demand for engineers with expertise in the area of nuclear phenomena. Since its inception, the department has grown substantially and now offers a Bachelor of Science degree and three advanced degrees.

The Nuclear Engineering Building houses the department, and its teaching and research facilities. There exists, available for student use, equipment for monitoring, counting, and investigating various nuclear behaviors, as well as subcritical reactors. UT has several designated research contracts with the Oak Ridge National Laboratory (ORNL) which provides graduate students and faculty with unique research opportunities. Students are permitted to consider their time spent at ORNL toward their twenty hour/week requirement for research assistantship funding. With the exception of a few foreign students, nearly all of the graduate students are receiving financial assistance. Three people have teaching assistantships, with no actual teaching responsibilities; rather, they assist the professors. The remainder of the students have research assistantships. During 1976-1977, approximately one half million dollars composed the research budget, and the largest portion of that supported graduate students.

PROGRAM REQUIREMENTS

Admission to the Master of Engineering program requires the applicant to have an undergraduate degree in nuclear engineering, or the close equivalent of one, as stipulated by Engineers' Council for Professional Development accreditation requirements. This degree requires the completion of thirty-six quarter hours of course work, eighteen of which must be in nuclear engineering. A minimum of nine hours of design project, thesis, or twenty-four hours of Nuclear Engineering Practice (5980) must be completed. Documentary proof of significant engineering experience may be submitted in lieu of the design project, the thesis, or the practice, but in that case a total of forty-five hours of course work are required. Students must take nine quarter credits of work outside of the department. A minimum of one-third of the program must be in engineering design, and one-third of, or a combination of, advanced mathematics, computer sciences, basic sciences, or engineering sciences. A final oral examination on all work presented for a degree must be passed. This degree has been offered for the past two years.

Students from other disciplines of engineering and physics are welcome in this department. It is the feeling of a program source that these students enrich the entire department's log of information with their varied backgrounds. These students must take articulation work in nuclear engineering areas in which they are felt to be deficient enough to prevent them from enrolling in courses that they need. Two plans are available for students to choose from. The first requires forty-five credits of advisory committee approved courses. This program includes eighteen quarter hours in nuclear engineering, a minor of nine hours in mathematics, and a master's thesis. At the completion of the thesis and all graduate course work, a final examination must be passed.

An alternate program is available for M.S. students which involves engineering practice rather than a thesis. Those who elect this plan must complete thirty-six quarter hours of work, similar to the first M.S. plan. In addition, they must complete twenty-four quarter hours of Nuclear Engineering Practice (5980). Usually, the student registers for six hours of 5980 each quarter and investigates problems assigned by a member of the faculty. At the end of each quarter the student must submit a written report and make an oral presentation of the work. Upon completion of the program the student must pass a comprehensive examination over his/her program.

Students in the field of nuclear engineering desiring to study for the degree of Doctor of Philosophy must have a Bachelor of Science or a Master of Science degree from a recognized university with a major in engineering or physics, and present at least a B average. All candidates will be required to demonstrate general competence in the preliminary examination in the areas of engineering science, mathematics, and physics. At the same time all candidates will be required to demonstrate special competence in nuclear design.

Specific requirements for the Ph.D. in nuclear engineering include: a minimum of seventy-two quarter hours of credit beyond the bachelor's degree, exclusive of credit for the M.S. thesis or Nuclear Engineering Practice; a minimum of thirty-six credits in doctoral research; a minimum of forty-five hours in courses numbered 5000 (i.e., graduate level) or above, with at least twelve credits of 6000 level courses (exclusive of thesis or dissertation credit);

a minimum of eighteen quarter hours in mathematics or computer science in courses beyond nuclear engineering baccalaureate requirements (must be 4000 level or above); a minimum of nine quarter hours in courses numbered 5000 or above from a department other than nuclear engineering; and a reading knowledge of one foreign language will be determined by the student's doctoral committee.

CURRENT FACULTY, STUDENTS, GRADUATES

The faculty of the Department of Nuclear Engineering is composed of nine full-time persons, all of whom divide their attentions between teaching and research to varying degrees. Fifty graduate students are enrolled in this department, the largest portion of whom are pursuing the M.S. degree. This year it is expected that eight master's degrees and five Ph.D.'s will be awarded.

A follow-up survey showed that of twenty-two Ph.D. graduates, fifteen are employed in the state, and of the twenty-eight master's degrees awarded, fifteen are working in Tennessee. Twenty of these people are working at ORNL, and four are with the Tennessee Valley Authority (TVA). Now most graduates are looking to the private sector for employment, and with excellent success.

PROGRAM PROJECTIONS

Acknowledging our nation's critical need for the development of new energy sources and technologies, there is currently being planned an option in nuclear fusion technology. Also, a fuel management and waste disposal program is being designed to meet the need for engineers with expertise in the area of nuclear waste storage and ultimate disposal.

COURSE DESCRIPTION

5002 Non-Thesis Graduation Completion - Required for the non-thesis student not otherwise registered during any quarter when such a student uses university facilities and/or faculty time before degree is completed. (3 q.h.)

5110-20-30 Transport Processes in Nuclear Engineering - Momentum and heat transport; development of conservation equations: elementary theory of turbulence; heat transfer and flow through conduits; conduction; radiation; reactor core thermal analysis. (3 q.h. each)

5210 System Dynamics - Transient analysis, Laplace transforms, frequency response, stability (linear and nonlinear), and sensitivity analysis by state variable methods. Dynamic analysis of distributed systems. (3 q.h.)

5220 Reactor System Dynamics - Application of methods of general system dynamics to reactor systems. Modeling of neutronic and non-neutronic processes. Dynamics, stability, and control of zero power reactors and power reactor systems. (3 q.h.)

5230 Experimental Methods in Reactor Dynamics - Methods of measuring system dynamic characteristics in the time domain and frequency domain. Measurement, analysis, and interpretation of dynamics data using random and deterministic system perturbation. (3 q.h.)

5240 Reactor Instrumentation - Principles and applications of instrument components and systems for the operation, control, and safety of nuclear reactors; role of instrumentation in public health and safety; engineered safeguards for nuclear power plants. (3 q.h.)

5310-20-30 Nuclear Systems Reliability - Principles of system reliability analysis as applied to nuclear systems. Both qualitative and quantitative methods are included. (3 q.h. each)

5710-20-30 Nuclear Design - Development and application of analytical techniques for neutronic aspect of nuclear reactor core design. Techniques considered are multi-group discrete ordinate theory, multigroup PN theory, integral transport theory, perturbation theory, and others. The generation of the required multigroup constants is formulated starting with the available point data and using the Nordheim treatment in the slowing down region and gas kernel in the thermal region. (3 q.h. each)

5740 Reactor Shielding - Application of analytic solutions of Boltzman transport equation to shield design problems. Spherical harmonics, moments methods, numerical solutions, adjoint calculations, and invariant imbedding cases studied. (3 q.h.)

5790 Monte Carlo Shield Design - Analysis of radiation transport problems in shielding by the Monte Carlo Analysis method. Including random sampling, evaluation of integrals, analog particle transport, techniques of variance reduction. (3 q.h.)

5840-50 Fast Breeder Reactors - Special characteristics of fast breeder reactors, with emphasis on the LMFBR. The need for breeders; neutron physics and thermal characteristics of the reactor core; development status of engineering components; fuel cycle cost analysis; safety; coolants other than sodium; world status of development. (3 q.h. each)

5910-20 Advanced Nuclear Reactor Design - Factors affecting nuclear reactor design, and optimization with respect to performance criteria. Integration of neutronic, mechanical and thermal flow systems. Cycle, reactor plant cost estimating. (3 q.h. each)

5970 Special Topics in Nuclear Engineering - Lectures and recitation on recent advances in nuclear engineering. (3 q.h.)

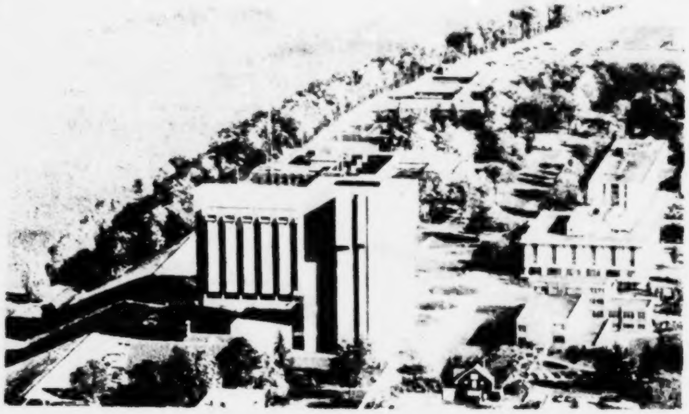
5980 Nuclear Engineering Practice - Experiences in solving and reporting on engineering problems. Only Alternate Plan students may take this course. (3-12 q.h.)

6110-20-30 Selected Topics in Reactor Theory - Special topics related to reactor theory such as transport theory, control rod theory, and perturbation theory. Selected topics from the literature. (3 q.h. each)

6140 Radiation Shielding - Advanced topics in radiation shielding. Monte Carlo techniques and space radiation problems. Natural space radiators, dose conversion, probability, etc. Selected neutron, gamma, and space-radiation shielding problems. (3 q.h.)

6150 Reactor Dynamics - Special topics in reactor dynamics and control. (3 q.h.)

6710 Two-Phase Flow and Heat Transfer - Pool boiling and flow boiling; hydrodynamics of two-phase flow, boiling crises, two-phase instabilities. (3 q.h.)



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APPENDICES

Photo reprinted from the University of Illinois Institute of Technology Booklet

Photo reprinted from the Indiana University of Public and Environmental Affairs Catalog 1977-78

APPENDIX I

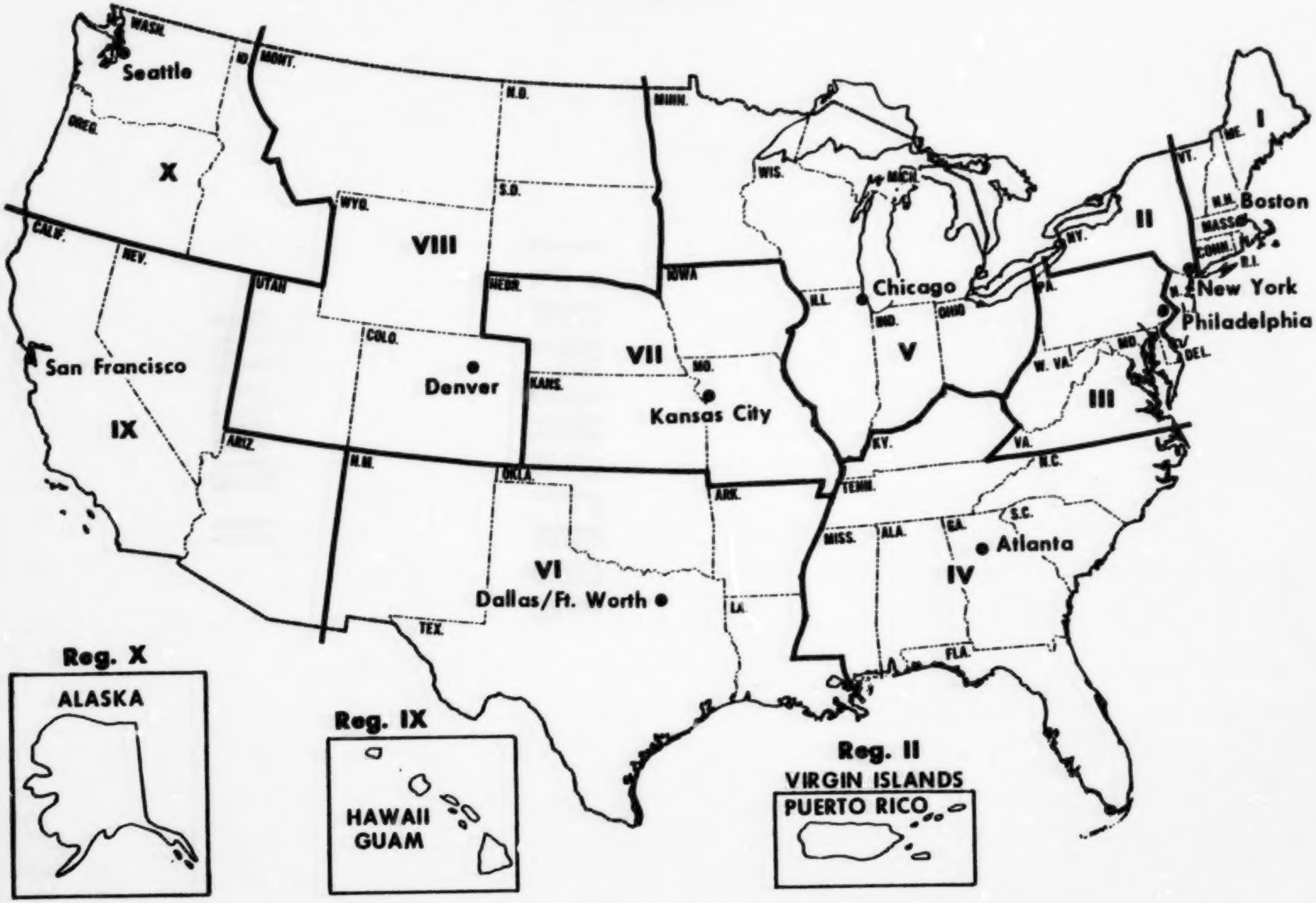
Degree Abbreviations

A.A.	Associate of Arts
A.A.Ag.	Associate of (in) Applied Agriculture
A.Ag.	Associate of (in) Agriculture
A.A.P.C.T.	Associate Degree in Air Pollution Control Technology
A.A.S.	Associate of Applied Science
A.B.	Bachelor of Arts
A.D.	Associate Degree
A.E.T.	Associate in Engineering Technology
A.M.T.	Associate of Mining Technology
A.N.E.T.	Associate of Nuclear Engineering Technology
A.S.	Associate in Science
A.S.E.M.T.	Associate of Science in Engineering Mining Technology
A.T.	Associate of Technology
B.A.	Bachelor of Arts
B.E.M.T.	Bachelor of Engineering in Mining Technology
B.S.	Bachelor of Science
B.S. (N.E.)	Bachelor of Science in Nuclear Engineering
B.S. (N.E.S.)	Bachelor of Science (Nuclear Engineering Sciences)
B.S. (N.R.)	Bachelor of Science in Natural Resources
B.S.A.	Bachelor of Science in Agriculture
B.S.C.E.	Bachelor of Science in Civil Engineering
B.S.Ch.E.	Bachelor of Science in Chemical Engineering
B.S.E.	Bachelor of Science in Engineering
B.S.E.H.	Bachelor of Science in Environmental Health
B.S.E. (N.E.)	Bachelor of Science (Nuclear Engineering)
B.S.E.S.	Bachelor of Science in Engineering Sciences
B.S.N.E.	Bachelor of Science in Nuclear Engineering
B.T.	Bachelor of Technology
Cert.	Certificate

D.E.	Doctor of Engineering
D.P.H.	Doctor of Public Health
D.S.	Doctor of Science
D.S. (Hyg.)	Doctor of Science Hygiene
D.Sc.	Doctor of Science
Dr.P.H.	Doctor of Public Health
E.E.	Environmental Engineer
Eng.	Engineer
Engr.	Engineer
Engr.Sc.D.	Doctor of Engineering Science
Env.E.	Environmental Engineer
Envir.Eng.	Environmental Engineer
M.A.	Master of Arts
M.Ag.	Master of Agriculture
M.Agr.	Master of Agriculture
M.A.S.	Master of Applied Science
M.C.E.	Master of Civil Engineering
M.E.	Master of Engineering
M.E.E.E.	Master of Engineering in Environmental Engineering
M.E.A.S.	Master of Environmental Arts and Science
M.E.H.S.	Master of Environmental Health Sciences
M.E.M.	Master of Environmental Management
M.E.P.C.	Master in Environmental Pollution Control
M.Eng.	Master of Engineering
M.Engr.	Master of Engineering
M.F.	Master of Forestry
M.M.E.	Master of Mechanical Engineering
M.P.	Master of Philosophy
M.P.A.	Master of Public Affairs
M.P.H.	Master of Public Health
M.P.P.P.M.	Master of Plant Protection and Pest Management

M.P.S.	Master of Professional Studies
M.S.	Master of Science
M.S. (Hyg.)	Master of Science Hygiene
M.S.C.E.	Master of Science in Civil Engineering
M.S.Ch.E.	Master of Science in Chemical Engineering
M.S.E.	Master of Science in Engineering
M.S.E.E.	Master of Science in Environmental Engineering
M.S.En.E.	Master of Science in Environmental Engineering
M.S.Eng. S.	Master of Science in Environmental Engineering
M.S.Eng. Sci.	Master of Science in Engineering Science
M.S.E.H.	Master of Science in Environmental Health
M.S.E.M.P.	Master of Science in Energy Management and Policy
M.S.E.S.	Master of Science in Environmental Science (Studies)
M.S.P.H.	Master of Science in Public Health
M.S.(S.E.)	Master of Science in Sanitary Engineering
M.S.(S.S.)	Master of Science in Sanitary Science
N.E.	Nuclear Engineering
Nuc. Eng.	Nuclear Engineering
Ph.D.	Doctor of Philosophy
S.B.	Bachelor of Science
Sc.D.	Doctor of Science
S.M.	Master of Science

STANDARD REGIONAL BOUNDARIES
TEN REGIONS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MISS.
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GA.
Atlanta
VI
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Dallas/Ft. Worth
LA.
TEX.
FLA.
Reg. X
ALASKA
Reg. IX
HAWAII
GUAM
Reg. II
VIRGIN ISLANDS
PUERTO RICO

II

TERMINOLOGY

ACT (American College Testing) and SAT (Scholastic Aptitude Test) - Standardized examinations which are intended to provide applicants and institutions with a numerical statement of an individual's ability and readiness to successfully complete college/university level work.

Co-op program - A plan whereby a student receives financial assistance and academic credit under the direction of a cooperating employment site representative and a faculty advisor in exchange for an agreed upon condition of employment. Students must complete all degree requirements as per the norm.

Course - For the purpose of this study, a course is considered a unit of a program, in which a body of knowledge is presented, the satisfactory completion of which leads to the awarding of a predetermined or individually arranged number of credits.

ECPD (Engineers' Council for Professional Development) - Accrediting body for programs in engineering technology.

ERIC (Educational Resources Information Center) - A national information system designed and developed by the U.S. Office of Education, and now supported and operated by the National Institute of Education (NIE), for providing ready access to descriptions of exemplary programs, research and development efforts, and related information that can be used in developing more effective educational programs.

GRE (Graduate Record Examination) - (General Aptitude) An examination of verbal and mathematical competency and aptitude, which is designed to provide a numerical indication of an individual's ability to successfully complete advanced level work. For the purposes of the study, the GRE will not refer to the Advanced Examinations.

Internship/Applied Study Term - An arrangement which is intended to provide a simulation of work experience under the direction of academic advisors and is designed to be an integral segment of an individual's academic program. (College credit may be given.)

IRIS (Instructional Resources Information System) - A computerized information base listing materials relating to education and training in the water quality control field, which is located in the National Training and Operational Technology Center of the U.S. Environmental Protection Agency.

MEDLINE - Computerized literature search services with application to medical information.

NTIS (National Technical Information Service) - Computerized literature search services.

Program - For the purpose of this study, a plan of study, either completely prescribed, or containing options, with an identity of its own, and standard rules and procedures, the satisfaction of which may lead to a degree, certificate, or diploma.

Quarter hours - vs. - Semester hours - One semester hour is the credit equivalent to one and a half quarter hours.

Standard Federal Boundaries - Geographic division of the United States for the purposes of decentralized administration; in this report also referred to as EPA regions (see map on preceding page).

TOXLINE - Computerized literature search services with particular application to the recall of information concerning toxic substances.

WRSIC (Water Resources Scientific Information Center) - Collects, screens, organizes and disseminates reports in water resources.

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APPENDIX IV

PARTICIPATING INSTITUTIONS BY ENVIRONMENTAL CATEGORY

ATEGORY	INSTITUTION	LOCATION
R	Carnegie-Mellon University	Pittsburgh, PA
	Clemson University	Clemson, SC
	Drexel University	Philadelphia, PA
	George Washington University-NASA	Hampton, VA
	Harvard University School of Public Health	Boston, MA
	Hudson Valley Community College	Troy, NY
	Massachusetts Institute of Technology	Ithaca, NY
	Michigan Technological University	Houghton, MI
	Middlesex County College	Edison, NJ
	Muskingum Area Technical College	Zanesville, OH
	New Jersey Institute of Technology	Newark, NJ
	North Carolina State University	Chapel Hill, NC
	North Dakota State School of Science	Wahpeton, ND
	Northeastern University	Boston, MA
	Ohio State University	Columbus, OH
	Portland State University	Portland, OR
	Prairie State Community College	Chicago Heights, IL
	Purdue University	West Layfayette, IN
	Rensselaer Polytechnic Institute	Troy, NY
	Rutgers-The State University of New Jersey	New Brunswick, NJ
	Springfield Technical Community College	Springfield, MA
	Stevens Institute of Technology	Hoboken, NJ
	Sumter University	Sumter, SC
	Syracuse University	Syracuse, NY
	Temple University	Philadelphia, PA
	The Pennsylvania State University	University Park, PA
	University of Cincinnati	Cincinnati, OH
	University of Delaware	Newark, DE
	University of Florida	Gainesville, FL
	University of Iowa	Iowa City, IA
	University of Kentucky	Lexington, KY
	University of Maryland	College Park, MD
	University of Michigan	Ann Arbor, MI
	University of Missouri-Rolla	Rolla, MO
	University of North Carolina	Chapel Hill, NC
	University of Pittsburgh	Pittsburgh, PA
	University of Tennessee	Knoxville, TN
	University of Texas-Austin	Austin, TX
	University of Washington	Seattle, WA
	University of Wisconsin-Milwaukee	Milwaukee, WI
	Vanderbilt University	Nashville, TN
	Washington State University	Pullman, WA
	Washington University	St. Louis, MO
	West Virginia University	Morgantown, WV
	Yale University	New Haven, CT

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PARTICIPATING INSTITUTIONS BY ENVIRONMENTAL CATEGORY

CATEGORY	INSTITUTION	LOCATION
COMPOSITE:	Antioch College	Yellow Springs, OH
	Baylor University	Waco, TX
	Bemidji State University	Bemidji, MN
	California Institute of Technology	Pasadena, CA
	California Polytechnic State University	San Luis Obispo, CA
	Catholic University of America	Washington, DC
	Carnegie-Mellon University	Pittsburgh, PA
	Chattanooga State Technical Community College	Chattanooga, TN
	Clarkson College	Potsdam, NY
	Clemson University	Clemson, SC
	Cornell University	Ithaca, NY
	Delaware Technical and Community College	Newark, DE
	Delgado College	New Orleans, LA
	Drexel University	Philadelphia, PA
	Duke University	Durham, NC
	East Central Oklahoma State University	Ada, OK
	East Tennessee State University	Johnson City, TN
	Evergreen State College	Olympia, WA
	Ferris State College	Big Rapids, MI
	Florida International University	Miami, FL
	Georgia Institute of Technology	Atlanta, GA
	Heed University	Hollywood, FL
	Hocking Technical College	Nelsonville, OH
	Howard University	Washington, DC
	Hunter College	New York, NY
	Indiana University	Bloomington, IN
	Iowa State University	Ames, IA
	Johns Hopkins University	Baltimore, MD
	Kansas State University	Manhattan, KS
	Kirkwood Community College	Cedar Rapids, IA
	Lamar University	Beaumont, TX
	Macalester College	St. Paul, MN
	Massachusetts Institute of Technology	Cambridge, MA
	McNeese State University	Lake Charles, LA
	Miami University	Oxford, OH
	Michigan State University	East Lansing, MI
	Middle Tennessee State University	Murfreesboro, TN
	Morehead State University	Morehead, KY
	Muskingum Area Technical College	Zanesville, OH
	New Jersey Institute of Technology	Newark, NJ
	North Carolina State University	Raleigh, NC
	Northland College	Ashland, WI
	Ohio State University	Columbus, OH

APPENDIX IV

PARTICIPATING INSTITUTIONS BY ENVIRONMENTAL CATEGORY

ATEGORY	INSTITUTION	LOCATION
MPOSITE: ont'd)	Ohio University	Athens, OH
	Oscar Rose Junior College	Midwest City, OK
	OSU Oklahoma City Technical Institute	Oklahoma City, OK
	Polytechnical Institute of New York	Brooklyn, NY
	Princeton University	Princeton, NJ
	Purdue University	West Lafayette, IN
	Raymond Walters General and Technical College (University of Cincinnati	Cincinnati, OH
	Rensselaer Polytechnical Institute	Troy, NY
	Rutgers University	New Brunswick, NJ
	Sam Houston State University	Huntsville, TX
	Sangamon State University	Springfield, IL
	Slippery Rock State College	Slippery Rock, PA
	Springfield Technical and Community College	Springfield, MA
	Stevens Institute of Technology	Hoboken, NJ
	Syracuse University	Syracuse, NY
	Temple University	Philadelphia, PA
	Texas A & M University	College Station, TX
	The Cooper Union	New York, NY
	The Pennsylvania State University	University Park, PA
	University of Alabama	University, AL
	University of Alaska	Fairbanks, AK
	University of Arkansas	Fayetteville, AR
	University of California-Santa Barbara	Santa Barbara, CA
	University of Cincinnati	Cincinnati, OH
	University of Delaware	Newark, DE
	University of Florida	Gainesville, FL
	University of Georgia	Athens, GA
	University of Kansas	Lawrence, KS
	University of Louisville	Louisville, KY
	University of Maine-Orono	Orono, Maine
	University of Michigan	Ann Arbor, MI
	University of Minnesota	Minneapolis, MN
	University of North Carolina	Chapel Hill, NC
	University of Oklahoma	Norman, OK
	University of Pittsburgh	Pittsburgh, PA
	University of Tennessee	Knoxville, TN
	University of Toledo	Toledo, OH
	University of Utah	Salt Lake City, UT
	University of Washington	Seattle, WA
	University of Wisconsin-Green Bay	Green Bay, WI
	University of Wisconsin-Madison	Madison, WI
	Utah State University	Logan, UT

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PARTICIPATING INSTITUTIONS BY ENVIRONMENTAL CATEGORY

CATEGORY	INSTITUTION	LOCATION
COMPOSITE: (Cont'd)	Vanderbilt University	Nashville, TN
	Virginia Polytechnic Institute and State University	Blacksburg, VA
	Washington State University	Pullman, WA
	Western Kentucky University	Bowling Green, KY
	Western Washington University (Huxley College of Environmental Studies)	Bellingham, WA
	West Virginia University	Morgantown, WV
	Yale University	New Haven, CT
ENERGY:	Bluefield State College	Bluefield, WV
	Brigham Young University	Provo, UT
	Carnegie-Mellon University	Pittsburgh, PA
	Columbia University	New York, NY
	Cornell University	New York, NY
	Georgia Institute of Technology	Atlanta, GA
	Hartford State Technical College	Hartford, CT
	Kansas State University	Manhattan, KS
	Lamar University	Beaumont, TX
	Massachusetts Institute of Technology	Cambridge, MA
	Morehead State University	Morehead, KY
	Muskingum Area Technical College	Zanesville, OH
	Oregon State University	Corvallis, OR
	Pikeville College	Pikeville, KY
	Polytechnic Institute of New York	Brooklyn, NY
	Princeton University	Princeton, NJ
	Purdue University	West Lafayette, IN
	Rensselaer Polytechnic Institute	Troy, NY
	Southern Technical Institute	Marietta, GA
	Texas State Technical Institute	Waco, TX
	The Pennsylvania State University	University Park, PA
	University of California-Berkeley	Berkeley, CA
	University of Florida	Gainesville, FL
	University of Kentucky	Lexington, KY
	University of New Mexico	Albuquerque, NM
	University of Pennsylvania	Philadelphia, PA
	University of Tennessee	Knoxville, TN
	West Virginia Institute of Technology	Montgomery, WV
	West Virginia University	Morgantown, WV

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PARTICIPATING INSTITUTIONS BY ENVIRONMENTAL CATEGORY

ATEGORY	INSTITUTION	LOCATION
ISE:	George Washington University-NASA	Hampton, VA
	Georgia Institute of Technology	Altanta, GA
	Massachusetts Institute of Technology	Cambridge, MA
	Memphis State University	Memphis, TN
	North Carolina State University	Raleigh, NC
	The Pennsylvania State University	University Park, PA
	University of Cincinnati	Cincinnati, OH
	University of Pittsburgh	Pittsburgh, PA
	University of Tennessee	Knoxville, TN
	University of Tennessee Center for Health Sciences	Memphis, TN
STICIDES:	Abraham Baldwin Agricultural College	Tifton, GA
	Broward Community College	Ft. Lauderdale, FL
	Central Technical Community College	Hastings, NE
	Delgado Community College	New Orleans, LA
	Harvard University School of Public Health	Boston, MA
	Mississippi State University	Mississippi State, MS
	New Mexico State University	Las Cruces, NM
	North Carolina State University	Raleigh, NC
	Ohio State University	Columbus, OH
	Oregon State University	Corvallis, OR
	Rutgers State University of New Jersey	New Brunswick, NJ
	State University of New York at Farmingdale	Farmingdale, NY
	Texas A & M University	College Station, TX
	The Pennsylvania State University	University Park, PA
	University of California-Berkeley	Berkeley, CA
	University of California-Davis	Davis, CA
	University of California-Riverside	Riverside, CA
	University of Cincinnati	Cincinnati, OH
	University of Delaware	Newark, DE
	University of Georgia	Athens, GA
	University of Iowa	Iowa City, IA
	University of Maryland	College Park, MD
	University of New Hampshire	Durham, NH
	University of Pittsburgh	Pittsburgh, PA
	University of Rochester	Rochester, NY
	Utah State University	Logan, UT

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PARTICIPATING INSTITUTIONS BY ENVIRONMENTAL CATEGORY

CATEGORY	INSTITUTION	LOCATION
POTABLE WATER:	Atlanta University Center/Georgia Institute of Technology	Atlanta, GA
	Brigham Young University	Provo, UT
	California State University	Sacramento, CA
	Carnegie-Mellon University	Pittsburgh, PA
	Casper College	Casper, WY
	Central Technical Community College	Hastings, NE
	Clarkson College	Potsdam, NY
	Clemson University	Clemson, SC
	Colorado State University	Fort Collins, CO
	Community College of Denver-Red Rocks	Golden, CO
	Cornell University	Ithaca, NY
	Delgado College	New Orleans, LA
	Drexel University	Philadelphia, PA
	East Maine Vocational Technical Institute	Bangor, ME
	Hudson Valley Community College	Troy, NY
	Illinois Institute of Technology	Chicago, IL
	Iowa State University	Ames, IA
	J. Sargeant Reynolds Community College	Richmond, VA
	Kansas State University	Manhattan, KS
	Kirkwood Community College	Cedar Rapids, IA
	Linn-Benton Community College	Albany, OR
	Manhattan College	New York, NY
	Marquette University	Milwaukee, WI
	Massachusetts Institute of Technology	Cambridge, MA
	Miami-Dade Community College	Miami, FL
	Michigan Technological University	Houghton, MI
	Middlesex Community College	Edison, NJ
	Missouri Southern State College	Joplin, MO
	Montana State University	Bozeman, MT
	Muskingum Area Technical College	Zanesville, OH
	Northeastern University	Boston, MA
	Northern Montana College	Havre, MT
	Ohio State University	Columbus, OH
	Operator Training Center	Murfreesboro, TN
	Oregon Institute of Technology	Klamath Falls, OR
	Oscar Rose Junior College	Midwest City, OK
	Purdue University	West Lafayette, IN
	Rensselaer Polytechnic Institute	Troy, NY
	Rice University	Houston, TX
	Rochester Institute of Technology	Rochester, NY
	Rutgers State University of New Jersey	New Brunswick, NJ
	Southern Illinois University	Edwardsville, IL

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PARTICIPATING INSTITUTIONS BY ENVIRONMENTAL CATEGORY

ATEGORY	INSTITUTION	LOCATION
TABLE WATER: ont'd)	Springfield Technical Community College	Springfield, MA
	Stanford University	Stanford, CA
	State University of New York at Buffalo	Buffalo, NY
	Stevens Institute of Technology	Hoboken, NJ
	Sumter Technical Community College	Sumter, SC
	Syracuse University	Syracuse, NY
	Temple University	Philadelphia, PA
	Texas State Technical Institute	Waco, TX
	The Pennsylvania State University	University Park, PA
	The Pennsylvania State University/ Capitol Campus	Middletown, PA
	Tufts University	Boston, MA
	Ulster County Community College	Stone Ridge, NY
	University of California-Berkeley	Berkeley, CA
	University of Florida	Gainesville, FL
	University of Hawaii	Honolulu, HI
	University of Iowa	Iowa City, IA
	University of Kansas	Lawrence, KS
	University of Kentucky	Lexington, KY
	University of Maine at Orono	Orono, ME
	University of Michigan	Ann Arbor, MI
	University of Missouri-Columbia	Columbia, MO
	University of Missouri-Rolla	Rolla, MO
	University of Nebraska	Lincoln, NE
	University of North Carolina	Chapel Hill, NC
	University of Pennsylvania	Philadelphia, PA
	University of Pittsburgh	Pittsburgh, PA
	University of Rhode Island	Kingston, RI
	University of Tennessee	Knoxville, TN
	University of Texas-Austin	Austin, TX
	University of Wisconsin-Madison	Madison, WI
	University of Wyoming	Laramie, WY
	Utah State University	Logan, UT
	Vanderbilt University	Nashville, TN
	Virginia Polytechnic Institute and State University	Blacksburg, VA
	Water and Wastewater Technical School	Neosho, MO
	West Georgia College	Carrollton, GA
	West Virginia University	Morgantown, WV
	Wytheville Community College	Wytheville, VA

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PARTICIPATING INSTITUTIONS BY ENVIRONMENTAL CATEGORY

CATEGORY	INSTITUTION	LOCATION
RADIATION:	Central Florida Community College	Ocala, FL
	Chattanooga State Technical Community College	Chattanooga, TN
	Columbia University	New York, NY
	Cornell University	Ithaca, NY
	Hartford State Technical College	Hartford, CT
	Harvard University School of Public Health	Boston, MA
	Kansas State University	Manhattan, KS
	Massachusetts Institute of Technology	Cambridge, MA
	Memphis State University	Memphis, TN
	Missouri Southern State College	Joplin, MO
	Oak Ridge Associated Universities	Oak Ridge, TN
	Oklahoma State University	Stillwater, OK
	Rensselaer Polytechnic Institute	Troy, NY
	Rutgers State University of New Jersey	New Brunswick, NJ
	St. Louis Community College at Forest Park	St. Louis, MO
	Southern Technical Institute	Marietta, GA
	The Pennsylvania State University	University Park, PA
	University of Florida	Gainesville, FL
	University of Kansas	Lawrence, KS
	University of Lowell	Lowell, MA
	University of Maryland	College Park, MD
	University of Michigan	Ann Arbor, MI
	University of North Carolina	Chapel Hill, NC
	University of Pittsburgh	Pittsburgh, PA
	University of Tennessee	Knoxville, TN
SOLID WASTE:	Carnegie-Mellon University	Pittsburgh, PA
	Clarkson College	Potsdam, NY
	Cornell University	New York, NY
	Drexel University	Philadelphia, PA
	Hofstra University	Hempstead, NY
	Michigan Technological University	Houghton, MI
	Rensselaer Polytechnic Institute	Troy, NY
	Temple University	Philadelphia, PA
	The Pennsylvania State University	University Park, PA
	University of Iowa	Iowa City, IA
	University of Missouri-Rolla	Rolla, MO
	University of Pittsburgh	Pittsburgh, PA
	Vanderbilt University	Nashville, TN
	West Virginia University	Morgantown, WV
	Wilson County Technical Institute	Wilson, NC
	Yale University	New Haven, CT

APPENDIX IV

PARTICIPATING INSTITUTIONS BY ENVIRONMENTAL CATEGORY

CATEGORY	INSTITUTION	LOCATION
ASTEWATER:	Atlanta University Center/ Georgia Institute of Technology	Atlanta, GA
	Brigham Young University	Provo, UT
	California State University-Sacramento	Sacramento, CA
	Carnegie-Mellon University	Pittsburgh, PA
	Casper College	Casper, WY
	Central Technical Community College	Hastings, NE
	Charles County Community College	La Plata, MD
	Clarkson College	Potsdam, NY
	Clemson University	Clemson, SC
	Colorado State University	Fort Collins, CO
	Community College of Denver-Red Rocks	Golden, CO
	Cornell University	Ithaca, NY
	Delgado College	New Orleans, LA
	Drexel University	Philadelphia, PA
	East Maine Vocational Technical Institute	Bangor, ME
	Greenville Technical College	Greenville, SC
	Harvard University	Cambridge, MA
	Hudson Valley Community College	Troy, NY
	Illinois Institute of Technology	Chicago, IL
	Iowa State University	Ames, IA
	J. Sargeant Reynolds Community College	Richmond, VA
	Kansas State University	Manhattan, KS
	Kirkwood Community College	Cedar Rapids, IA
	Linn-Benton Community College	Albany, OR
	Manhattan College	New York, NY
	Marquette Technical University	Milwaukee, WI
	Massachusetts Institute of Technology	Cambridge, MA
	Miami-Dade Community College	Miami, FL
	Michigan Technological University	Houghton, MI
	Middlesex County College	Edison, NJ
	Missouri Southern State College	Joplin, MO
	Montana State University	Bozeman, MT
	Muskingum Area Technical College	Zanesville, OH
	New England Regional Wastewater Institute	S. Portland, ME
	New Jersey Institute of Technology	Newark, NJ
	Northeastern University	Boston, MA
	Northern Montana College	Havre, MT
	Ohio State University	Columbus, OH
	Operator Training Center	Murfreesboro, TN
	Oregon Institute of Technology	Klamath Falls, OR
	Oscar Rose Junior College	Midwest City, OK

APPENDIX IV

PARTICIPATING INSTITUTIONS BY ENVIRONMENTAL CATEGORY

CATEGORY	INSTITUTION	LOCATION
WASTEWATER: (Cont'd)	Purdue University	West Lafayette, IN
	Rensselaer Polytechnic Institute	Troy, NY
	Rice University	Houston, TX
	Rochester University	Rochester, NY
	Rutgers State University of New Jersey	New Brunswick, NJ
	Southern Illinois University	Edwardsville, IL
	Springfield Technical and Community College	Springfield, MA
	Stanford University	Stanford, CA
	State Technical Institute at Memphis	Memphis, TN
	State University of New York-Buffalo	Buffalo, NY
	Stevens Institute of Technology	Hoboken, NJ
	Sumter Technical Community College	Sumter, SC
	Syracuse University	Syracuse, NY
	Temple University	Philadelphia, PA
	Texas State Technical Institute	Waco, TX
	The Pennsylvania State University	University Park, PA
	The Pennsylvania State University/ Capitol Campus	Middletown, PA
	Tufts University	Boston, MA
	Ulster County Community College	Stone Ridge, NY
	University of California-Berkeley	Berkeley, CA
	University of Florida	Gainesville, FL
	University of Hawaii	Honolulu HI
	University of Kansas	Lawrence, KS
	University of Kentucky	Lexington, KY
	University of Lowell	Lowell, MA
	University of Maine at Orono	Orono, ME
	University of Missouri-Columbia	Columbia, MO
	University of Missouri-Rolla	Rolla, MO
	University of Nebraska	Lincoln, NE
	University of North Carolina	Chapel Hill, NC
	University of Pittsburgh	Pittsburgh, PA
	University of Rhode Island	Kingston, RI
	University of Tennessee	Knoxville, TN
	University of Texas	Austin, TX
	University of Wisconsin-Madison	Madison, WI
	University of Wyoming	Laramie, WY
	Utah State University	Logan, UT
	Vanderbilt University	Nashville, TN
	Virginia Polytechnic Institute and State University	Blacksburg, VA
	Water and Wastewater Technical School	Neosho, MO
	West Georgia College	Carrollton, GA
	West Virginia University	Morgantown, WV
	Wytheville Community College	Wytheville, VA

APPENDIX V

CATALOGS REVIEWED

STATE	INSTITUTION	LOCATION
AL	Alabama A & M University	Huntsville
	Alabama Christian College	Montgomery
	Alabama Lutheran Junior College	Selma
	Alexander City State Junior College	Alexander City
	Athens State College	Athens
	Auburn University	Auburn
	Auburn University at Montgomery	Montgomery
	Birmingham-Southern College	Birmingham
	Brewer State Junior College	Fayette
	Enterprise State Junior College	Enterprise
	Faulkner State Junior College	Bay Minette
	Gadsden State Junior College	Gadsden
	George C. Wallace State Community College	Dothan
	George C. Wallace State Community College	Selma
	Jacksonville State University	Jacksonville
	Jefferson Davis State Junior College	Brewton
	Jefferson State Junior College	Birmingham
	John C. Calhoun State Community College	Decatur
	Judson College	Marion
	Livingston University	Livingston
	Lawson State Community College	Birmingham
	Lurleen B. Wallace State Junior College	Andalusia
	Marion Military Institute	Marion
	Miles College	Birmingham
	Mobile College	Mobile
	Northeast Alabama State Junior College	Rainsville
	Northwest Alabama State Junior College	Phil Campbell
	Oakwood College	Huntsville
	Samford University	Birmingham
	Selma University	Selma
	Snead State Junior College	Boaz
	Southeastern Bible College	Birmingham
	Southern Benedictine College	Saint Bernard
	Southern Union State Junior College	Wadley
	Spring Hill College	Mobile
	Stillman College	Tuscaloosa
	Talladega College	Talladega
	Troy State University	Troy
	Tuskeegee Institute	Tuskeegee Institute
	University of Alabama	University
	University of Alabama in Birmingham	Birmingham
	University of Alabama in Huntsville	Huntsville
	University of Montevallo	Montevallo
	University of North Alabama	Florence
	University of South Alabama	Mobile
	Walker College	Jasper
AK	Sheldon Jackson College	Sitka
	University of Alaska-Fairbanks	Fairbanks
	University of Alaska Juneau Senior College	Juneau
AS	American Samoa Community College	Pago Pago
AZ	American Graduate School of International Management	Glendale
	Arizona State University	Tempe
	Arizona Western College	Yuma

APPENDIX V
CATALOGS REVIEWED

STATE	INSTITUTION	LOCATION
	Central Arizona College	Coolidge
	Cochise College	Douglas
	College of Ganado	Ganado
	DeVry Institute of Technology	Phoenix
	Eastern Arizona College	Thatcher
	Grand Canyon College	Phoenix
	Maricopa County Community	
	College System Office	Phoenix
	Glendale Community College	Glendale
	Maricopa Technical Community College	Phoenix
	Mesa Community College	Mesa
	Phoenix College	Phoenix
	Scottsdale Community College	Scottsdale
	Mohave Community College	Kingman
	Navajo Community College	Tsaile
	Northern Arizona University	Flagstaff
	Northland Pioneer College	Holbrook
	Pima Community College	Tucson
	Southwestern College	Phoenix
	University of Arizona	Tucson
	Yavapai College	Prescott
AR	Arkansas College	Batesville
	Arkansas State University-Main Campus	State University
	Arkansas State University-Beebe Branch	Beebe
	Arkansas Tech University	Russellville
	Central Baptist College	Conway
	College of the Ozarks	Clarksville
	Crowley's Ridge College	Paragould
	Garland County Community College	Hot Springs
	Harding College-Main Campus	Searcy
	Henderson State University	Arkadelphia
	Hendrix College	Conway
	John Brown University	Siloam Springs
	Mississippi County Community College	Blytheville
	Quachita Baptist University	Arkadelphia
	Philander Smith College	Little Rock
	Phillips County Community College	Helena
	Southern Arkansas University	Magnolia
	Southern Arkansas University Southwest Technical Institute	East Camden
	Southern Baptist College	Walnut Ridge
	Southern State College	Magnolia
	University of Arkansas-Main Campus	Fayetteville
	University of Arkansas-Little Rock	Little Rock
	University of Arkansas Medical Sciences Campus	Little Rock
	University of Arkansas-Monticello	Monticello
	Westlark Community College	Fort Smith
CA	Allan Hancock College	Santa Maria
	Ambassador College	Pasadena
	American Baptist Seminary of the West-Central Office	Berkeley
	American Baptist Seminary of the West-Covina	Covina
	Armstrong College	Berkeley
	Azusa Pacific College	Azusa
	Bakersfield College	Bakersfield
	Barstow College	Barstow
	Bauder College	Sacramento
	Bethany Bible College	Santa Cruz
	Biola College	La Mirada
	Brooks College	Long Beach

APPENDIX V
CATALOGS REVIEWED

STATE	INSTITUTION	LOCATION
	Brooks Institute of Santa Barbara	Santa Barbara
	Butte College	Oroville
	Cabrillo College	Aptos
	California Baptist College	Riverside
	California College of Arts and Crafts	Oakland
	California Institute of the Arts	Valencia
	California Institute of Asian Studies	San Francisco
	California Institute of Technology	Pasadena
	California Lutheran College	Thousand Oaks
	California Maritime Academy	Vallejo
	California State College-San Bernadino	San Bernardino
	California State College-Stanislaus	Turlock
	California Polytechnic State University-San Luis Obispo	San Luis Obispo
	California State University-Fresno	Fresno
	California State University-Fullerton	Fullerton
	California State University-Hayward	Hayward
	California State University-Long Beach	Long Beach
	California State University-Los Angeles	Los Angeles
	California State University-Sacramento	Sacramento
	San Diego State University	San Diego
	San Jose State University	San Jose
	Cerritos College	Norwalk
	Cerro Coso Community College	Ridgecrest
	Chapman College	Orange
	Christian Heritage College	El Cajon
	Church Divinity School of the Pacific	Berkeley
	Citrus College	Azusa
	Claremont Colleges-System Office	Claremont
	Claremont Men's College	Claremont
	Claremont University Center and Graduate School	Claremont
	Harvey Mudd College	Claremont
	Pitzer College	Claremont
	Pomona College	Claremont
	Scripps College	Claremont
	Coast Community College-System Office	Costa Mesa
	Golden West College	Huntington Beach
	Orange Coast College	Costa Mesa
	Cogswell College	San Francisco
	Colegio De La Tierra	Goshen
	College of the Canyons	Valencia
	College of the Desert	Palm Desert
	College of Marin	Kentfield
	College of Notre Dame	Belmont
	College of the Redwoods	Eureka
	College of the Siskiyous	Weed
	Columbia Junior College	Columbia
	Compton Community College	Compton
	Contra Costa Community College-System Office	
	Diablo Valley College	Pleasant Hill
	Cuesta College	San Luis Obispo
	Cypress College	Cypress
	Dominican College of San Rafael	San Rafael
	El Camino College	Torrance
	Foothill-De Anza Community College District-System Office	Los Altos Hills
	De Anza College	Cupertino
	Foothill College	Los Altos Hills
	Fuller Theological Seminary	Pasadena
	Gavilan College	Gilroy
	Glendale Community College	Glendale
	Golden Gate University	San Francisco
	Grossmont College	El Cajon
	Hartnell College	Salinas
	Holy Family College	Mission San Jose

APPENDIX V
CATALOGS REVIEWED

STATE	INSTITUTION	LOCATION
	Holy Names College	Oakland
	Immaculate Heart College	Los Angeles
	Indian Valley Colleges	Novato
	John F. Kennedy University	Orinda
	Lake Tahoe Community College	S. Lake Tahoe
	Lassen College	Susanville
	LaVerne College	La Verne
	L.I.F.E. Bible College	Los Angeles
	Lincoln University	San Francisco
	Lone Mountain College	San Francisco
	Long Beach City College	Long Beach
	Los Angeles Baptist College	Newhall
	Los Angeles Community College-System Office	Los Angeles
	East Los Angeles College	Los Angeles
	Los Angeles City College	Los Angeles
	Los Angeles Harbor College	Wilmington
	Los Angeles Mission College	San Fernando
	Los Angeles Pierce College	Woodland Hills
	Los Angeles Southwest College	Los Angeles
	Los Angeles Valley College	Van Nuys
	West Los Angeles College	Culver City
	Los Rios Community College-System Office	Sacramento
	Cosumnes River College	Sacramento
	Sacramento City College	Sacramento
	Loyla Marymount University	Los Angeles
	Marymount Palos Verdes College	Rancho Palos Verdes
	Mendocino College	Ukiah
	Menlo College	Menlo Park
	Mennonite Brethren Biblical Seminary	Fresno
	Merced College	Merced
	Mills College	Oakland
	Monterey Institute for Foreign Studies	Monterey
	Monterey Peninsula College	Monterey
	Mount San Antonio College	Walnut
	Mount San Jacinto College	San Jacinto
	Napa College	Napa
	National University	San Diego
	New College of California	San Francisco
	Northrop University	Inglewood
	Occidental College	Los Angeles
	Ohlone College	Fremont
	Otis Art Institute of Los Angeles County	Los Angeles
	Pacific Christian College	Fullerton
	Pacific College	Fresno
	Pacific Oaks College	Pasadena
	Pacific School of Religion	Berkeley
	Pacific Union College	Angwin
	Palomar College	San Marcos
	Palo Verde College	Blythe
	Pasadena City College	Pasadena
	Patten Bible College	Oakland
	Pepperdine University	Malibu
	Peralta Community Colleges-System Office	Oakland
	College of Alameda	Alameda
	Point Loma College	San Diego
	Porterville College	Porterville
	Rand Graduate Institute of Policy Studies	Santa Monica
	Riverside City College	Riverside
	Rosemead Graduate School of Psychology	Rosemead
	Saddleback Community College	Mission Viejo
	Saint Mary's College of California	Moraga

APPENDIX V

CATALOGS REVIEWED

STATE	INSTITUTION	LOCATION
	Saint Patrick's College	Mountain View
	San Diego Community College-Central Office	San Diego
	San Diego Community College-City College	San Diego
	San Diego Community College-Evening College	
	San Francisco Art Institute	San Francisco
	San Francisco Conservatory of Music	San Francisco
	San Francisco Theological Seminary	San Anselmo
	San Joaquin Delta College	Stockton
	San Jose Community College District-	
	Evergreen Valley College	San Jose
	San Jose City College	San Jose
	San Mateo County Community College District-System Office	San Mateo
	Canada College	Redwood City
	College of San Mateo	San Mateo
	Skyline College	San Bruno
	Santa Ana College	Santa Ana
	Santa Barbara City College	Santa Barbara
	Santa Monica College	Santa Monica
	Santa Rosa Junior College	Santa Rosa
	Shasta College	Redding
	Sierra College	Rocklin
	Simpson College	San Francisco
	Solano Community College	Suisun City
	Southern California College	Costa Mesa
	Southern California College of Optometry	Fullerton
	Southwestern University School of Law	Los Angeles
	Stanford University	Stanford
	State Center Community College District	
	Fresno City College	Fresno
	Reedley College	Reedley
	Taft College	Taft
	United States International University	San Diego
	University of California-Berkeley	Berkeley
	University of California-Davis	Davis
	University of California Hastings College of Law	San Francisco
	University of California-Irvine	Irvine
	University of California-Los Angeles	Los Angeles
	University of California-Riverside	Riverside
	University of California-San Francisco	San Francisco
	University of California-Santa Barbara	Santa Barbara
	University of the Pacific	Stockton
	University of Redlands	Redlands
	University of San Diego	San Diego
	University of San Francisco	San Francisco
	University of Santa Clara	Santa Clara
	University of Southern California	Los Angeles
	University of West Los Angeles	Culver City
	Ventura County Community College District	
	Moorpark College	Moorpark
	Oxnard College	Oxnard
	Ventura College	Ventura
	West Coast Bible College	Fresno
	West Coast University Central Office	Los Angeles
	West Coast University Orange County Center	Orange
	Western State University College of Law-Orange County	Fullerton
	Western State University College of Law-San Diego	San Diego
	West Hills College	Coalinga
	Westmont College	Santa Barbara
	West Valley College	Saratoga

APPENDIX V

CATALOGS REVIEWED

STATE	INSTITUTION	LOCATION
	Whittier College	Whittier
	Woodbury University	Los Angeles
	The Wright Institute	Berkeley
	Yuba College	Marysville
CO	Adams State College	Alamosa
	Aims Community College	Greeley
	Arapahoe Community College	Littleton
	Colorado College	Colorado Springs
	Colorado Mountain College-East Campus	Leadville
	Colorado Mountain College-West Campus	Glenwood Springs
	Colorado School of Mines	Golden
	Colorado State University	Fort Collins
	Colorado Technical College	Manitou Springs
	Colorado Women's College	Denver
	Community College of Denver-Auraria Campus	Denver
	Community College of Denver-North Campus	Denver
	Community College of Denver-Red Rocks Campus	Golden
	Conservative Baptist Theological Seminary	Denver
	El Paso Community College	Colorado Springs
	Fort Lewis College	Durango
	Iliff School of Theology	Denver
	Lamar Community College	Lamar
	Loretto Heights College	Denver
	Mesa College	Grand Junction
	Metropolitan State College	Denver
	Morgan Community College	Fort Morgan
	Northeastern Junior College	Sterling
	Ortero Junior College	La Junta
	Regis College	Denver
	Rockmont College	Denver
	Saint Thomas Seminary	Denver
	Trinidad State Junior College	Trinidad
	University of Colorado-Boulder	Boulder
	University of Colorado-Colorado Springs	Colorado Springs
	University of Colorado-Denver	Denver
	University of Denver	Denver
	University of Denver College of Law	Denver
	University of Northern Colorado	Greeley
	University of Southern Colorado	Pueblo
	Western Bible College	Morrison
	Western State College of Colorado	Gunnison
CT	Albertus Magnus College	New Haven
	Annhurst College	Woodstock
	Bridgeport Engineering Institute	Bridgeport
	Connecticut College	New London
	Eastern Connecticut State College	Willimnatic
	Greater Hartford Community College	Hartford
	Hartford State Technical College	Hartford
	Housatonic Regional Community College	Bridgeport
	Mattuck Community College	Waterbury
	Middlesex Community College	Middletown
	Mitchell College	New London
	Mohegan Community College	Norwich
	Northwestern Connecticut Community College	Winsted
	Norwalk Community College	Norwald
	Post Junior College	Waterbury
	Quinebaug Valley Community College	Danielson
	Saint Joseph College	West Hartford

APPENDIX V
CATALOGS REVIEWED

STATE	INSTITUTION	LOCATION
	Thames Valley State Technical College	Norwich
	Trinity College	Hartford
	Tunxis Community College	Farmington
	University of Bridgeport	Bridgeport
	University of Hartford	West Hartford
	University of New Haven	West Haven
	Yale University	New Haven
DE	Delaware State College	Dover
	Delaware Technical and Community College	Dover
	Goldey Beacom College	Wilmington
	University of Delaware	Newark
	Wesley College	Dover
DC	American University	Washington
	Catholic University of America	Washington
	District of Columbia Teachers College	Washington
	Gallaudet College	Washington
	George Washington University	Washington
	Howard University	Washington
	Mount Vernon College	Washington
	Trinity College	Washington
FL	Barry College	Miami
	Brevard Community College	Cocoa
	Broward Community College	Fort Lauderdale
	Central Florida Community College	Ocala
	Chipola Junior College	Marianna
	College of Boca Raton	Boca Raton
	Daytona Beach Community College	Daytona Beach
	Eckerd College	St. Petersburg
	Edison Community College	Fort Meyers
	Embry-Riddle Aeronautical University	Daytona Beach
	Flagler College	St. Augustine
	Florida A & M University	Tallahassee
	Florida Atlantic University	Boca Raton
	Florida College	Temple Terrace
	Florida International University	Miami
	Florida Junior College	Jacksonville
	Florida Keys Community College	Key West
	Florida Southern College	Lakeland
	Florida Technological University	Orlando
	Fort Lauderdale College	Fort Lauderdale
	Gulf Coast Community College	Panama City
	Heed University	Hollywood
	Hillsborough Community College	Tampa
	Indian River Community College	Fort Pierce
	Jacksonville University	Jacksonville
	Jones College	Jacksonville
	Lake City Community College	Lake City
	Lake-Sumter Community College	Leesburg
	Manatee Junior College	Bradenton
	Miami Christian College	Miami
	Miami-Dade Community College	Miami
	North Florida Junior College	Madison
	Nova University	Fort Lauderdale
	Okaloosa-Walton Junior College	Niceville
	Palm Beach Atlantic College	West Palm Beach
	Palm Beach Junior College	Lake Worth
	Pensacola Junior College	Pensacola
	Polk Community College	Winter Haven

APPENDIX V

CATALOGS REVIEWED

STATE	INSTITUTION	LOCATION
	Rollins College	Winter Park
	Saint Johns River Junior College	Palatka
	Saint Leo College	Saint Leo
	Santa Fe Community College	Gainesville
	Seminole Community College	Sanford
	South-Eastern Bible College	Lakeland
	South Florida Junior College	Avon Park
	University of Florida	Gainesville
	University of Miami	Coral Gables
	University of North Florida	Jacksonville
	Warner Southern College	Lake Wales
	Webber College	Babson Park
GA	Abraham Baldwin Agricultural College	Tifton
	Agnes Scott College	Decatur
	Albany Area Vocational Technical School	Albany
	Albany Junior College	Albany
	Albany State College	Albany
	Andrew College	Cuthbert
	Armstrong State College	Savannah
	Atlanta Christian College	East Point
	Atlanta Junior College	Atlanta
	Atlanta University	Atlanta
	Augusta College	Augusta
	Bainbridge Junior College	Bainbridge
	Berry College	Mount Berry
	Brenau College	Gainesville
	Brewton-Parker College	Mount Vernon
	Carroll County Area Vocational-Technical School	Carrollton
	Carver Bible Institute and College	Atlanta
	Clark College	Atlanta
	Clayton Junior College	Morrow
	Columbus College	Columbus
	Dalton Junior College	Dalton
	DeKalb Community College	Clarkston
	Emanuel County Junior College	Swainsboro
	Emory University	Atlanta
	Fort Valley State College	Fort Valley
	Gainesville Junior College	Gainesville
	Georgia College	Milledgeville
	Georgia Institute of Technology	Atlanta
	Georgia Military College	Milledgeville
	Georgia Southern College	Statesboro
	Georgia Southwestern College	Americus
	Georgia State University	Atlanta
	Gordon Junior College	Barnesville
	Kennesaw Junior College	Marietta
	LaGrange College	LaGrange
	Macon Junior College	Macon
	Marietta-Cobb Area Vocational Technical School	Marietta
	Mercer University	Macon
	Mercer University in Atlanta	Atlanta
	Middle Georgia College	Cochran
	Morehouse College	Atlanta
	Moultrie Area Vocational-Technical School	Moultrie
	North Georgia College	Dahlonega
	North Georgia Technical and Vocational School	Clarkesville
	Oglethorpe College	Atlanta
	Pickens Area Vocational-Technical School	Jasper
	Piedmont College	Demorest
	Reinhardt College	Waleska

APPENDIX V

CATALOGS REVIEWED

STATE	INSTITUTION	LOCATION
	Savannah Area Vocational Technical School	Savannah
	Savannah State College	Savannah
	Shorter College	Rome
	South Georgia College	Douglas
	South Georgia Technical and Vocational School	Americus
	Southern Technical Institute	Marietta
	Swainsboro Area Vocational-Technical School	Swainsboro
	Thomas Area Vocational-Technical School	Thomasville
	Tift College	Forsyth
	Toccoa Falls College	Toccoa Falls
	Troup County Area Vocational Technical School	LaGrange
	Truett McConnell College	Cleveland
	University of Georgia	Athens
	Upson County Area Vocational-Technical School	Thomaston
	Valdosta State College	Valdosta
	Valdosta Technical School	Valdosta
	Walker County Area Technical School	Rock Spring
	Waycross-Ware Area Technical School	Waycross
	Wesleyan College	Macon
	West Georgia College	Carrollton
	Young Harris College	Young Harris
HI	Brigham Young University-Hawaii Campus	Laie Oahu
	Chaminade College of Honolulu	Honolulu
	Hawaii Pacific College	Honolulu
	University of Hawaii-Honolulu Community College	Honolulu
	University of Hawaii-Kapiolani Community College	Honolulu
	University of Hawaii-Kauai Community College	Lihue
	University of Hawaii-Leeward Community College	Pearl City
	University of Hawaii-Manoa	Honolulu
	University of Hawaii-Maui Community College	Kahului
	University of Hawaii-Windward Community College	Kaneohe
ID	Boise State University	Boise
	College of Southern Idaho	Twin Falls
	Idaho State University	Pocatello
	North Idaho College	Coeur D'Alene
	Northwest Nazarene College	Nampa
	Ricks College	Rexburg
	University of Idaho	Moscow
IL	Augustana College	Rock Island
	Aurora College	Aurora
	Barat College	Lake Forest
	Belleville Area College	Belleville
	Blackburn College	Carlinville
	Black Hawk College	Moline
	Bradley University	Peoria
	Carl Sandburg College	Galesburg
	Central YMCA Community College	Chicago
	Chicago College of Osteopathic Medicine	Chicago
	Chicago State University	Chicago
	College of DuPage	Glen Ellyn

APPENDIX V

CATALOGS REVIEWED

STATE	INSTITUTION	LOCATION
	College of Lake County	Grayslake
	College of St. Francis	Joliet
	College of the University of Chicago	Chicago
	Danville Junior College	Danville
	DeLourdes College	Des Plaines
	DePaul University	Chicago
	DeVry Institute of Technology	Chicago
	Eastern Illinois University	Charleston
	Elgin Community College	Elgin
	Elmhurst College	Elmhurst
	Eureka College	Eureka
	George Williams College	Downers Grove
	Governors State University	Park Forest South
	Greenville College	Greenville
	Highland Community College	Freeport
	Illinois Benedictine College	Lisle
	Illinois Central College	East Peoria
	Illinois College	Jacksonville
	Illinois College of Optometry	Chicago
	Illinois College of Podiatric Medicine	Chicago
	Illinois Institute of Technology	Chicago
	Illinois State University	Normal
	Illinois Valley Community College	Oglesby
	Illinois Wesleyan University	Bloomington
	Joliet Junior College	Joliet
	Judson College	Elgin
	Kankakee Community College	Kankakee
	Kendall College	Evanston
	Kishwaukee College	Malta
	Knox College	Galesburg
	Lake Forest College	Evanston
	Lakeland College	Mattoon
	Lewis and Clark Community College	Godfrey
	Lincoln Trail College	Robinson
	Logan (John A.) College	Carterville
	Loyola University of Chicago	Chicago
	MacMurray College	Jacksonville
	McHenry County College	Crystal Lake
	McKendree College	Lebanon
	Meadville Theological School	Lombard
	Millikin University	Decatur
	Moraine Valley Community College	Palos Hills
	National College of Chiropractic	Lombard
	North Central College	Naperville
	Northeastern Illinois University	Chicago
	Northern Baptist Theological Seminary	Lombard
	Northern Illinois University	DeKalb
	Northwestern University	Evanston
	Oakton Community College	Morton Grove
	Olivet Nazarene College	Kankakee
	Olney Central College	Mt. Carmel
	Prairie State Community College	Chicago Heights
	Rockford College	Rockford
	Rock Valley College	Rockford
	Roosevelt University	Chicago
	Rush University, College of Nursing and Allied Health Sciences	Chicago
	Rush University, Rush Medical College	Chicago
	Sangamon State University	Springfield
	Sauk Valley College	Dixon
	Southern Illinois University	Carbondale
	Southern Illinois University	Edwardsville
	Spertus College of Judaica	Chicago
	Spoon River College	Canton
	Springfield College in Illinois	Springfield

APPENDIX V
CATALOGS REVIEWED

STATE	INSTITUTION	LOCATION
	State Community College of East Saint Louis, Illinois	East St. Louis
	Thornton Community College	South Holland
	Triton College	River Grove
	University of Health Sciences, The Chicago Medical School	Chicago
	University of Illinois at Chicago Circle	Chicago
	University of Illinois at the Medical Center, School of Public Health	Chicago
	University of Illinois at Urbana-Champaign	Urbana-Champaign
	Wabash Valley College	Mt. Carmel
	Waubonsee Community College	Sugar Grove
	Western Illinois University	Macomb
	Wheaton College	Wheaton
	William Rainey Harper College	Palatine
IN	Anderson College	Anderson
	Associated Mennonite Biblical Seminary	Elkhart
	Ball State University	Muncie
	Bethel College	Mishawaka
	Butler University	Indianapolis
	DePauw University	Greencastle
	Earlham College	Richmond
	Franklin College	Franklin
	Goshen College	Goshen
	Grace College	Winona Lake
	Hanover College	Hanover
	Holy Cross Junior College	Notre Dame
	Huntington College	Huntington
	Indiana Central College	Indianapolis
	Indiana Institute of Technology	Fort Wayne
	Indiana State University	Evansville
	Indiana University	Bloomington
	Indiana University-East	Richmond
	Indiana University-Kokomo	Kokomo
	Indiana University-Northwest	Gary
	Indiana University-South Bend	South Bend
	Indiana University-Southeast	New Albany
	Indiana University-Purdue University at Fort Wayne	Fort Wayne
	Indiana Vocational Technical College	Indianapolis
	International Junior College	Fort Wayne
	Manchester College	North Manchester
	Marian College	Indianapolis
	Marion College	Marion
	Oakland College	Oakland City
	Purdue State University	Muncie
	Purdue University	West Lafayette
	Purdue University-Calumet	Calumet
	Purdue University-North Central	Westville
	Rose-Hulman Institute of Technology	Terre Haute
	Saint Joseph's College	Rensselaer
	Saint Mary's College	Notre Dame
	Saint Mary of the Woods College	Saint Mary of the Woods
	Saint Meinard College	St. Meinard
	Taylor University	Upland
	Tri-State University	Angola
	University of Evansville	Evansville
	University of Notre Dame	South Bend
	Valparaiso University	Valparaiso
	Vincennes University	Vincennes
	Wabash College	Crawfordsville

APPENDIX V

CATALOGS REVIEWED

STATE	INSTITUTION	LOCATION
IA	Area One Vocational-Technical School	Calmar and Dubuque
	Briar Cliff College	Sioux City
	Central College	Pella
	Clarke College	Dubuque
	Coe College	Cedar Rapids
	Cornell College	Mt. Vernon
	Des Moines Area Community College	Ankeny
	Drake University	Des Moines
	Ellsworth Community College	Iowa Falls
	Grinnell College	Grinnell
	Hawkeye Institute of Technology	Waterloo
	Iowa Central Community College	Fort Dodge
	Iowa Lakes Community College	Estherville
	Iowa State University	Ames
	Iowa Wesleyan College	Mount Pleasant
	Iowa Western Community College	Council Bluffs
	Kirkwood Community College	Cedar Rapids
	Loras College	Dubuque
	Luther College	Decorah
	Marshalltown Community College	Marshalltown
	Marycrest College	Davenport
	Morningside College	Sioux City
	Mount Mercy College	Cedar Rapids
	North Iowa Area Community College	Mason City
	Open Bible College	Des Moines
	Palmer College of Chiropractic	Davenport
	Simpson College	Indianola
	Southeastern Community College	Burlington
	Southwestern Community College	Creston
	University of Dubuque	Dubuque
	University of Dubuque Theological Seminary	Dubuque
	University of Iowa	Iowa City
	University of Northern Iowa	Cedar Falls
	Upper Iowa University	Fayette
	Wartburg College	Waverly
	Wartburg Seminary	Dubuque
	Westmar College	LeMars
	Western Iowa Technical Community College	Sioux City
KS	Allen County Community Junior College	Iola
	Baker University	Baldwin
	Barton County Community College	Great Bend
	Benedictine College	Atchison
	Bethel College	North Newton
	Central College	McPherson
	Cloud County Community College	Concordia
	Coffeyville Community Junior College	Coffeyville
	Colby Community College	Colby
	Cowley County Community College	Arkansas City
	Dodge City Community College	Dodge City
	Donnelly College	Kansas City
	Emporia Kansas State College	Emporia
	Fort Hays Kansas State College	Hays
	Fort Scott Community College	Fort Scott
	Friends Bible College	Haviland
	Garden City Community College	Garden City
	Haskell Indian Junior College	Lawrence
	Hesston College	Hesston
	Highland Community Junior College	Highland
	Hutchinson Community Junior College	Hutchinson
	Independence Community Junior College	Independence
	Johnson County Community College	Overland Park
	Kansas City Community College	Kansas City

APPENDIX V
CATALOGS REVIEWED

STATE	INSTITUTION	LOCATION
	Kansas Newman College	Wichita
	Kansas State College of Pittsburg	Pittsburg
	Kansas State University	Manhattan
	Kansas Technical Institute	Salina
	Kansas Wesleyan	Salina
	Labette Community Junior College	Parsons
	Manhattan Christian College	Manhattan
	Marymount College of Kansas	Salina
	McPherson College	McPherson
	Mid-America Nazarene College	Olathe
	Neosho County Community Junior College	Chanute
	Ottawa University	Ottawa
	Pratt Community College	Pratt
	Saint John's College	Winfield
	Saint Mary College	Leavenworth
	Saint Mary of the Plains College	Dodge City
	Seward County Community College	Liberal
	Southwestern College in Kansas	Winfield
	Sterling College	Sterling
	Tabor College	Hillsboro
	The University of Kansas	Lawrence
	Washburn University of Topeka	Topeka
	Wichita State University	Wichita
KY	Alice Lloyd College	Pippa Passes
	Asbury College	Wilmore
	Bellarmine College	Louisville
	Berea College	Berea
	Brescia College	Owensboro
	Campbellsville College	Campbellsville
	Centre College of Kentucky	Danville
	Cumberland College	Williamsburg
	Eastern Kentucky University	Richmond
	Georgetown College	Georgetown
	Jefferson Vocational Regional Office	Jeffersontown
	Kentucky Christian College	Grayson
	Kentucky State University	Frankfort
	Kentucky Wesleyan College	Owensboro
	Lees Junior College	Jackson
	Lindsey Wilson College	Columbia
	Midway College	Midway
	Morehead State University	Morehead
	Murray State University	Murray
	Pikeville College	Pikeville
	Saint Catharine College	Saint Catharine
	Southeastern Christian College	Winchester
	Sue Bennett College	London
	Thomas More College	Fort Mitchell
	Transylvania University	Lexington
	University of Kentucky	Lexington
	University of Kentucky Community College System	Lexington
	University of Louisville	Louisville
	Western Kentucky University	Bowling Green
LA	Bossier Parish Community College	Bossier City
	Centenary College of Louisiana	Shreveport
	Delgado College	New Orleans
	Dillard University	New Orleans
	Grambling State University	Grambling
	Louisiana State University-Central Office	Baton Rouge

APPENDIX V

CATALOGS REVIEWED

STATE	INSTITUTION	LOCATION
	Louisiana State University and Agricultural and Mechanical College at Baton Rouge	Baton Rouge
	Louisiana State University-Alexandria	Alexandria
	Louisiana State University-Eunice	Eunice
	Louisiana State University-Shreveport	Shreveport
	University of New Orleans	New Orleans
	Louisiana Tech University	Ruston
	McNeese State University	Lake Charles
	New Orleans Baptist Theological Seminary	New Orleans
	Northeast Louisiana University	Monroe
	Northwestern State University of Louisiana	Natchitoches
	Notre Dame Seminary School of Theology	New Orleans
	Our Lady of Holy Cross College	New Orleans
	Saint Bernard Parish Community College	Chalmette
	Saint Joseph Seminary College	Saint Benedict
	Saint Mary's Dominican College	New Orleans
	Southern University in New Orleans	New Orleans
	Tulane University of Louisiana	New Orleans
	Xavier University of Louisiana	New Orleans
ME	Bowdoin College	Brunswick
	Colby College	Waterville
	College of the Atlantic	Bar Harbor
	Eastern Maine Vocational and Technical Institute	Bangor
	Maine Maritime Academy	Castine
	Masson College	Springvale
	South Maine Vocational and Technical Institute	South Portland
	Unity College	Unity
	University of Maine at Orono	Orono
MD	Bowie State College	Bowie
	Catonsville Community College	Catonsville
	Charles County Community College	La Plata
	Chesapeake College	Wye Mills
	Columbia Union College	Takoma Park
	Community College of Baltimore	Baltimore
	Dundalk Community College	Baltimore
	Essex Community College	Baltimore County
	Garrett Community College	McHenry
	Goucher College	Towson
	Hagerstown Junior College	Hagerstown
	Harford Community College	Bel Air
	Hood College	Frederick
	Howard Community College	Columbia
	Johns Hopkins University	Baltimore
	Loyola College	Baltimore
	Montgomery College	Rockville
	Saint John's College	Annapolis
	Saint Mary's College of Maryland	Saint Mary's City
	Towson State College	Baltimore
	University of Baltimore	Baltimore
	University of Maryland	College Park
	Villa Julie College	Stevenson
	Washington College	Chestertown

APPENDIX V

CATALOGS REVIEWED

STATE	INSTITUTION	LOCATION
MA	Amherst College	Amherst
	Anna Maria College	Paxton
	Assumption College	Worcester
	Bay Path Junior College	Longmeadow
	Bentley College	Waltham
	Boston College	Chestnut Hill
	Boston University	Boston
	Gordon College	Wenham
	Hampshire College	Amherst
	Harvard University	Cambridge
	Lasell Junior College	Auburndale
	Lesley College	Cambridge
	Massachusetts Institute of Technology	Cambridge
	Merrimack College	North Andover
	Mount Holyoke College	South Hadley
	Nichols College	Dudley
	Northeastern University	Boston
	Regis College	Weston
	Simon's Rock	Great Barrington
	Smith College	Northampton
	Southeastern Massachusetts University	North Darmouth
	Springfield College	Springfield
	Springfield Technical Community College	Springfield
	Stonehill College	North Easton
	Suffolk University	Boston
	Tufts University	Medford
	University of Massachusetts	Boston
	Wentworth Institute	Boston
	Wheelock College	Boston
	Williams College	Williamstown
	Worcester Junior College	Worcester
	Worcester Polytechnic Institute	Worcester
MI	Alma College	Alma
	Alpena Community College	Alpena
	Andrews University	Berrien Springs
	Aquinas College	Grand Rapids
	Bay de Noc Community College	Escanaba
	Calvin College	Grand Rapids
	Calvin Theological Seminary	Grand Rapids
	Central Michigan University	Mount Pleasant
	Concordia Lutheran Junior College	Ann Arbor
	Delta College	University Center
	Detroit Institute of Technology	Detroit
	Eastern Michigan University	Ypsilanti
	Ferris State College	Big Rapids
	General Motors Institute	Flint
	Grace Bible College	Wyoming
	Grand Rapids Baptist College	Grand Rapids
	Grand Rapids Junior College	Grand Rapids
	Grand Valley State College	Allendale
	Highland Park Community College	Highland Park
	Hillsdale College	Hillsdale
	Hope College	Holland

APPENDIX V

CATALOGS REVIEWED

STATE	INSTITUTION	LOCATION
	Jackson Community College	Jackson
	Kalamazoo College	Kalamazoo
	Kalamazoo Valley Community College	Kalamazoo
	Kirtland Community College	Roscommon
	Lake Michigan College	Benton Harbor
	Lake Superior State College	Saulte Ste. Marie
	Lansing Community College	Lansing
	Macomb County Community College	Warren
	Madonna College	Livonia
	Marygrove College	Detroit
	Mercy College of Detroit	Detroit
	Merrill-Palmer Institute	Detroit
	Michigan Department of Education-Environmental Guidelines	Lansing
	Michigan State University	East Lansing
	Michigan Technological University	Houghton
	Mid Michigan Community College	Harrison
	Monroe County Community College	Monroe
	Montcalm Community College	Sidney
	Mott Community College	Flint
	Muskegon Business College	Muskegon
	Muskegon Community College	Muskegon
	Northern Michigan University	Marquette
	Northwestern Michigan College	Traverse City
	Oakland Community College	Bloomfield Hills
	Oakland University	Rochester
	Olivet College	Olivet
	Saginaw Valley State College	University Center
	Saint Mary's College	Orchard Lake
	Schoolcraft College	Livonia
	Shaw College at Detroit	Detroit
	Southwestern Michigan College	Dowagiac
	Spring Arbor College	Spring Arbor
	Suomi College	Hancock
	University of Detroit	Detroit
	University of Michigan	Ann Arbor
	Walsh College	Troy
	Washtenaw Community College	Ann Arbor
	Wayne County Community College	Detroit
	Wayne State University	Detroit
	Western Michigan University	Kalamazoo
	West Shore Community College	Scottville
	Western Theological Seminary	Holland
MN	Anoka-Ramsey Community College	Coon Rapids
	Augsburg College	Minneapolis
	Austin Community College	Austin
	Bemidji State University	Bemidji
	Bethany Lutheran College	Mankato
	Brainerd Community College	Brainerd
	Carleton College	Northfield
	College of Saint Benedict	St. Joseph
	College of St. Catherine	St. Paul
	College of St. Scholastica	Duluth
	College of St. Thomas	St. Paul
	Concordia College	Moorhead
	Crosier Seminary Junior College	Onamia
	Dr. Martin Luther College	New Ulm
	Fergus Falls Community College	Fergus Falls
	Hibbing Community College	Hibbing
	Itasca Community College	Grand Rapids
	Lakewood Community College	White Bear Lake
	Luther Theological Seminary	St. Paul
	Macalester College	St. Paul
	Mankato State University	Mankato

APPENDIX V

CATALOGS REVIEWED

STATE	INSTITUTION	LOCATION
	Mesabi Community College	Virginia
	Metropolitan Community College	Minneapolis
	Metropolitan State University	St. Paul
	Minneapolis College of Art and Design	Minneapolis
	Minnesota Bible College	Rochester
	Moorhead State College	Moorhead
	Normandale Community College	Bloomington
	North Hennepin Community College	Minneapolis
	Northland Community College	Thief River Falls
	Northwestern College	Roseville
	Rainy River Community College	International Falls
	Rochester Community College	Rocnester
	Saint John's University	Collegeville
	Saint Mary's College	Winona
	Southwest Minnesota State College	Marshall
	St. Cloud Area Vocational Technical Institute	St. Cloud
	St. Cloud State University	St. Cloud
	St. Mary's Junior College	Minneapolis
	St. Paul Bible College	Bible College
	United Theological Seminary of the Twin Cities	New Brighton
	University of Minnesota	Minneapolis
	Vermilion Community College	Ely
	William Mitchell College of Law	St. Paul
	Winona State University	Winona
	Worthington Community College	Worthington
MS	Alcorn State University	Lorman
	Belhaven College	Jackson
	Clarke College	Newton
	Coahama Junior College	Clarksdale
	Copiah-Lincoln Junior College	Wesson
	Delta State University	Cleveland
	East Central Junior College	Decatur
	East Mississippi Junior College	Scooba
	Hinds Junior College	Raymond
	Holmes Junior College	Goodman
	Itawamba Junior College	Fulton
	Jackson State University	Jackson
	John C. Stennis Vocational Complex	Dekalb
	Jones County Junior College	Ellisville
	Mary Holmes College	West Point
	Meridian Junior College	Meridian
	Millsaps College	Jackson
	Mississippi College	Clinton
	Mississippi Delta Junior College	Moorhead
	Mississippi Gulf Coast Junior College	Perkinston
	Mississippi Industrial College	Holly Springs
	Mississippi State University	Mississippi State
	Mississippi University for Women	Columbus
	Northeast Mississippi Junior College	Booneville
	Northwest Mississippi Junior College	Senatobia
	Pearl River Junior College	Poplarville
	Rust College	Holly Springs
	Southwest Mississippi Junior College	Summit
	Tougaloo College	Tougaloo
	University of Mississippi	University
	University of Mississippi Medical Center	Jackson
	University of Southern Mississippi	Hattiesburg
	Utica Junior College	Utica
	Wesley College	Florence
	William Carey College	Hattiesburg
	Wood Junior College	Mathiston

APPENDIX V

CATALOGS REVIEWED

STATE	INSTITUTION	LOCATION
MO	Assemblies of God Graduate School	Springfield
	Avila College	Kansas City
	Calvary Bible College	Kansas City
	Central Bible College	Springfield
	Central Methodist College	Fayette
	Central Missouri State University	Warrensburg
	Columbia College	Columbia
	Concordia Seminary	St. Louis
	Cottey College	Nevada
	Crowder College	Neosho
	Culver-Stockton College	Canton
	Fontbonne College	St. Louis
	Hannibal Lagrange College	Hannibal
	Harris Teachers College	St. Louis
	Jefferson College	Hillsboro
	Kansas City Art Institute	Kansas City
	Kansas City College of Osteopathic Medicine	Kansas City
	Logan College of Chiropractic	Chesterfield
	Longview Community College	Kansas City
	Maple Woods Community College	Kansas City
	Maryville College	St. Louis
	Meramec Community College	St. Louis
	Missouri Baptist College	St. Louis
	Missouri Southern State College	Joplin
	Moberly Area Junior College	Moberly
	Northeast Missouri State University	Kirksville
	Northwest Missouri State University	Maryville
	Rockhurst College	Kansas City
	Saint Louis College of Pharmacy	St. Louis
	Saint Louis Community College at Forest Park	St. Louis
	Saint Louis University	St. Louis
	Saint Paul's College	Concordia
	School of the Ozarks	Point Lookout
	Southwest Missouri State University	Springfield
	State Fair Community College	Sedalia
	Stephen's College	Columbia
	Tarkio College	Tarkio
	The Principia	St. Louis
	Three Rivers Community College	Poplar Bluff
	University of Missouri-Columbia	Columbia
	University of Missouri-Kansas City	Kansas City
	University of Missouri-Rolla	Rolla
	University of Missouri-St. Louis	St. Louis
	Washington University	St. Louis
	Water and Wastewater Technical School	Neosho
	Webster College	Webster
	Westminster College	Fulton
	William Jewell College	Kansas City
MT	Carroll College	Helena
	College of Great Falls	Great Falls
	Dawson College	Glendive
	Eastern Montana College	Billings
	Flathead Valley Community College	Kalispell
	Miles Community College	Miles City
	Montana College of Mineral Science and Technology	Butte
	Montana State University	Bozeman
	Northern Montana College	Havre
	Rocky Mountain College	Billings
	University of Montana	Missoula
	Western Montana College	Dillon

APPENDIX V

CATALOGS REVIEWED

STATE	INSTITUTION	LOCATION
NE	Central Technical Community College	Hastings
	Chadron State College	Chadron
	College of Saint Mary	Omaha
	Concordia College	Seward
	Creighton University	Omaha
	Dana College	Blair
	Doane College	Crete
	Grace College of the Bible	Omaha
	Hastings College	Hastings
	Kearney State College	Kearney
	McCook Community College	McCook
	Midland Lutheran College	Fremont
	Mid-Plains Community College	North Platte
	Northeast Technical Community College	Norfolk
	Platte Technical Community College	Columbus
	Southeast Community College	Lincoln
	Union College	Lincoln
	University of Mid-America	Lincoln
	University of Nebraska	Lincoln
	Wayne State College	Wayne
NV	University of Nevada-Las Vegas	Las Vegas
	University of Nevada-Reno	Reno
	Clark County Community College	Las Vegas
	Northern Nevada Community College	Elko
	Sierra Nevada College	Incline Village
	Western Nevada Community College	Carson City
NH	Colby-Sawyer College	New London
	Dartmouth College	Hanover
	Franklin Pierce College	Rindge
	New England College	Henniker
	NH Technical Institute	Concord
	NH Voc-Tech College of Berlin	Berlin
	NH Voc-Tech College of Claremont	Claremont
	NH Voc-Tech College of Laconia	Laconia
	NH Voc-Tech College of Manchester	Manchester
	NH Voc-Tech College of Nashua	Nashua
	NH Voc-Tech College of Portsmouth	Portsmouth
	Saint Anselm's College	Manchester
	University of New Hampshire	Durham
	White Pines College	Chester
NJ	Atlantic Community College	Mays Landing
	Bergen Community College	Paramus
	Brookdale Community College	Lincroft
	Burlington County College	Penberton
	Camden County College	Caldwell
	Centenary College for Women	Hackettstown
	County College of Morris	Dover
	Cumberland County College	Vineland
	Drew University	Madison
	Fairleigh Dickinson University	Rutherford
	Gloucester County College	Sewell
	Kean College of New Jersey	Union
	Mercer County Community College	Trenton
	Middlesex County College	Edison
	Montclair State College	Upper Montclair
	New Jersey Institute of Technology	Newark
	Ocean County College	Toms River
	Passaic County Community College	Paterson
	Princeton University	Princeton

APPENDIX V
CATALOGS REVIEWED

STATE	INSTITUTION	LOCATION
	Rider College	Trenton
	Rutgers the State University	New Brunswick
	Stevens Institute of Technology	Hoboken
	Trenton State College	Trenton
	Union College	Cranford
	Union County Technical Institute	Scotch Plains
	William Paterson College	Wayne
NM	College of the Southwest	Hobbs
	Eastern New Mexico University-Main Campus	Portales
	Eastern New Mexico University-Roswell	Roswell
	New Mexico Highlands University	Las Vegas
	New Mexico Institute of Mining and Technology	Socorro
	New Mexico Junior College	Hobbs
	New Mexico Military Institute	Roswell
	New Mexico State University-Las Cruces	Las Cruces
	New Mexico State University-San Juan	San Juan
	University of Albuquerque	Albuquerque
	University of New Mexico-Main Campus	Albuquerque
NY	Adelphi University	Garden City
	Albany College Pharmacy	Albany
	Albany Law School	Albany
	Alfred University	Alfred
	Bard College	Annandale-on-Hudson
	Bronx Community College	Bronx
	Brooklyn Law School	Brooklyn
	Canisius	Buffalo
	City University of New York	New York
	Clarkson College of Technology	Potsdam
	Colgate University	Hamilton
	College of Mt. Saint Vincent	Riverdale
	College of Saint Rose	Albany
	Columbia University	New York
	Concordia College	Bronxfille
	Cornell University	Ithaca
	Dowling College	Oakdale Long Island
	D'Youville College	Buffalo
	Erie Community College	Buffalo
	Hamilton College	Clinton
	Hartwick College	Oneonta
	Hilbert College	Hamburg
	Hobart-William Smith Colleges	Geneva
	Hofstra University	Hempstead
	Houghton College	Houghton
	Hudson Valley Community College	Troy
	Hunter College	New York
	Ithaca College	Ithaca
	King's College	Briarcliff Manor
	Long Island University	Greenvale
	Manhattan College	Bronx
	Medaille College	Buffalo
	Mercy College	Dobbs Ferry
	Molloy College	Rockville Centre
	New School for Social Research	New York
	New York Institute of Technology	Old Westbury
	New York Law School	New York
	Niagara University	Niagara University

APPENDIX V

CATALOGS REVIEWED

STATE	INSTITUTION	LOCATION
	Paul Smith's College of Arts & Science	Paul Smiths
	Polytechnic Institute of New York	Brooklyn
	Rensselaer Polytechnic Institute	Troy
	Roberts Wesleyan College	Rochester
	Rochester Institute of Technology	Rochester
	Rockefeller University	New York
	Saint Banaventure University	Saint Bonaventure
	Saint John Fisher College	Rochester
	Saint John's University	Jamaica
	Saint Lawrence University	Canton
	Saint Thomas Aquinas College	Sparkhill
	Skidmore College	Saratoga Springs
	Southampton College	Southampton
	State University of New York at Buffalo	Buffalo
	Syracuse University	Syracuse
	The Cooper Union	New York
	Trocaire College	Buffalo
	Ulster County Community College	Stone Ridge
	University of Rochester	Rochester
	Vassar College	Poughkeepsie
	Wagner College	Staten Island
	Webb Institute of Naval Architecture	Glen Cove
	Westchester Community College	Valhalla
NC	Anson Technical Institute	Ansonville
	Appalachian State University	Boone
	Asheville Buncombe Technical Institute	Asheville
	Atlantic Christian College	Wilson
	Beaufort County Technical Institute	Washington
	Belmont Abbey College	Belmont
	Bennett College	Greensboro
	Bladen Technical Institute	Dublin
	Blue Ridge Technical Institute	Flat Rock
	Brevard College	Brevard
	Campbell College	Buies Creek
	Cape Fear Technical Institute	Wilmington
	Carteret Technical Institute	Morehead City
	Catawba College	Salisbury
	Catawba Valley Technical Institute	Hickory
	Central Carolina Technical Institute	Sanford
	Central Piedmont Community College	Charlotte
	Chowan College	Murfreesboro
	Cleveland County Technical Institute	Shelby
	Coastal Carolina Community College	Jacksonville
	College of the Albemarle	Elizabeth City
	Craven Community College	New Bern
	Davidson College	Davidson
	Davidson County Community College	Lexington
	Duke University	Durham
	Durham College	Durham
	East Carolina University	Greenville
	Elon College	Elon College
	Fayetteville State University	Fayetteville
	Fayetteville Technical Institute	Fayetteville
	Gardner Webb College	Boiling Springs
	Gaston College	Dallas
	Greensboro College	Greensboro
	Guilford College	Greensboro
	Guilford Technical Institute	Jamestown
	Halifax Community College	Weldon
	Haywood Technical Institute	Clyde
	High Point College	High Point
	Isothermal Community College	Spindale
	James Sprunt Institute	Kenansville
	Johnson C. Smith University	Charlotte

APPENDIX V

CATALOGS REVIEWED

STATE	INSTITUTION	LOCATION
	Johnston Technical Institute	Smithfield
	Lees-McCrae College	Banner Elk
	Lenoir Community College	Kinston
	Lenoir-Rhyne College	Hickory
	Livingstone College	Salisbury
	Louisburg College	Louisburg
	Mars Hill College	Mars Hill
	Martin Community College	Williamston
	Mayland Technical Institute	Spruce Pine
	McDowell Technical Institute	Marion
	Meredith College	Raleigh
	Methodist College	Fayetteville
	Montreat-Anderson College	Montreat
	Mount Olive College	Mount Olive
	Nash Technical Institute	Rocky Mount
	North Carolina Agricultural and Technical State University	Greensboro
	North Carolina Central University	Durham
	North Carolina State University	Raleigh
	North Carolina Wesleyan College	Rocky Mount
	Pembroke State University	Pembroke
	Pfeiffer College	Misenheimer
	Piedmont Bible College	Winston-Salem
	Piedmont Technical Institute	Roxboro
	Pitt Technical Institute	Greenville
	Queens College	Charlotte
	Randolph Technical Institute	Asheboro
	Richmond Technical Institute	Hamlet
	Roanoke-Chowan Technical Institute	Ahoskie
	Robeson Technical Institute	Lumberton
	Rockingham Community College	Wentworth
	Rowan Technical Institute	Salisbury
	Saint Andrews Presbyterian College	Laurinburg
	Saint Augustine's College	Raleigh
	Saint Mary's College	Raleigh
	Salem College	Winston-Salem
	Sampson Technical Institute	Clinton
	Sandhills Community College	Carthage
	Shaw University	Raleigh
	Stanly Technical Institute	Albermarle
	Surry Community College	Dobson
	Technical Institute of Alamance	Burlington
	Tri-County Technical Institute	Murphy
	University of North Carolina at Chapel Hill	Chapel Hill
	University of North Carolina at Charlotte	Charlotte
	University of North Carolina at Greensboro	Greensboro
	University of North Carolina at Wilmington	Wilmington
	Wake Forest University	Winston-Salem
	Wake Technical Institute	Raleigh
	Warren Wilson College	Swannanoa
	Wayne Community College	Goldsboro
	Western Carolina University	Cullowhee
	Western Piedmont Community College	Morganton
	Wilkes Community College	Wilkesboro
	Wilson County Technical Institute	Wilson
	Wingate College	Wingate
	Winston-Salem State University	Winston-Salem

APPENDIX V

CATALOGS REVIEWED

STATE	INSTITUTION	LOCATION
ND	Bismarck Junior College	Bismarck
	Dickinson State College	Dickinson
	Jamestown College	Jamestown
	Lake Region Junior College	Devils Lake
	Mary College	Bismarck
	Mayville State College	Mayville
	Minot State College	Minot
	North Dakota State School of Science	Wahpeton
	North Dakota State University-Main Campus	Fargo
	North Dakota State University-Bottineau	Bottineau
	Trinity Bible Institute	Ellendale
	University of North Dakota-Main Campus	Grand Forks
	University of North Dakota-Williston	Williston
OH	Antioch College	Yellow Springs
	Art Academy of Cincinnati	Cincinnati
	Bluffton College	Bluffton
	Capital University	Columbus
	Case Western Reserve University	Cleveland
	Central Ohio Technical College	Newark
	Central State University	Wilberforce
	Cincinnati Bible College	Cincinnati
	Cincinnati Technical College	Cincinnati
	Clark Technical College	Springfield
	Cleveland Institute of Art	Cleveland
	Cleveland Institute of Music	Cleveland
	Cleveland State University	Cleveland
	College of Mount St. Joseph on the Ohio	Cincinnati
	College of Steubenville	Steubenville
	College of Wooster	Wooster
	Columbus College of Art and Design	Columbus
	Columbus Technical Institute	Columbus
	Cuyahoga Community College	Cleveland
	Davis Junior College	Toledo
	Defiance College	Defiance
	Denison University	Granville
	Franklin University	Columbus
	Hebrew Union College	Cincinnati
	Heidelberg College	Tiffin
	Hiram College	Hiram
	Hocking Technical College	Nelsonville
	Jefferson County Technical Institute	Steubenville
	John Carroll University	Cleveland
	Josephinum College of Liberal Arts	Worthington
	Kent State University	Kent
	Kenyon College	Gambier
	Kettering College of Medical Arts	Kettering
	Lakeland Community College	Mentor
	Lima Technical College	Lima
	Lorain County Community College	Elyria
	Lutheran Theological Seminary	Columbus
	Malone College	Canton
	Marietta College	Marietta
	Marion Technical College	Marion
	Medical College of Ohio	Toledo
	Miami-Jacobs Junior College	Dayton
	Miami University	Oxford
	Mount Union College	Alliance
	Mount Vernon Nazarene College	Mount Vernon
	Muskingum Area Technical College	Zanesville
	Muskingum College	New Concord
	National Training and Operational Technology Center (EPA)	Cincinnati
	North Central Technical College	Mansfield

APPENDIX V
CATALOGS REVIEWED

STATE	INSTITUTION	LOCATION
	Northwest Technical College	Archbold
	Notre Dame College	Cleveland
	Oberlin College	Oberlin
	Ohio Board of Regents-Technical Education Offerings	Columbus
	Ohio Dominican College	Columbus
	Ohio Northern University	Ada
	Ohio State University	Columbus
	Ohio University	Athens
	Ohio Wesleyan University	Delaware
	Owens Technical College	Perrysburg
	Saint John College of Cleveland	Cleveland
	Sinclair Community College	Dayton
	Stark Technical College	Canton
	Tiffin University	Tiffin
	United Theological Seminary	Dayton
	University of Cincinnati	Cincinnati
	University of Dayton	Dayton
	University of Toledo	Toledo
	Urbana College	Urbana
	Washington Technical College	Marietta
	Wittenberg University	Springfield
	Wright State University	Dayton
	Xavier University	Cincinnati
	Youngstown State University	Youngstown
OK	Bacone College	Muskogee
	Bartlesville Weslyan College	Bartlesville
	Bethany Nazarene College	Bethany
	Cameron University	Lawton
	Carl Albert Junior College	Poteau
	Central State University	Edmond
	Claremore Junior College	Claremore
	Connors State College	Warner
	East Central Oklahoma State University	Ada
	Eastern Oklahoma State College	Wilburton
	El Reno Junior College	El Reno
	Hillsdale Free Will Baptist College	Moore
	Midwest Christian College	Oklahoma City
	Murray State College	Tishomingo
	Northeastern Oklahoma Agricultural and Mechanical College	Miami
	Northeastern Oklahoma State University	Tahlequah
	Northern Oklahoma College	Tonkawa
	Northwesterm Oklahoma State University	Alva
	Oklahoma Baptist University	Shawnee
	Oklahoma Christian College	Oklahoma City
	Oklahoma City University	Oklahoma City
	Oklahoma Panhandle State University	Goodwell
	Oklahoma School of Business, Accountancy, Law and Finance	Tulsa
	Oklahoma State University-Main Campus	Stillwater
	Oklahoma State University-Oklahoma City	Oklahoma City
	Oral Roberts University	Tulsa
	Oscar Rose Junior College	Midwest City
	Phillips University	Enid
	Saint Gregory's College	Shawnee
	Sayre Junior College	Sayre
	Seminole Junior College	Seminole
	Southeastern Oklahoma State University	Durant
	South Oklahoma City Junior College	Oklahoma City
	Southwestern College	Oklahoma City
	Tulsa Junior College	Tulsa
	University of Oklahoma-Central Office	Norman

APPENDIX V
CATALOGS REVIEWED

STATE	INSTITUTION	LOCATION
	University of Oklahoma-Health Science Center	Oklahoma City
	University of Science and Arts of Oklahoma	Chickasha
	University of Tulsa	Tulsa
	Western Oklahoma State College	Altus
OR	Blue Mountain Community College	Pendleton
	Chemeketa Community College	Salem
	Clackamas Community College	Oregon City
	Clatsop Community College	Astoria
	Columbia Christian College	Portland
	Concordia College	Portland
	George Fox College	Newberg
	Judson Baptist College	Portland
	Lane Community College	Eugene
	Lewis and Clark College	Portland
	Linfield College	McMinnville
	Linn-Benton Community College	Albany
	Marylhurst Education Center	Marylhurst
	Mount Hood Community College	Gresham
	Multnomah School of the Bible	Portland
	Museum Art School	Portland
	Oregon State Higher Education District	
	Eastern Oregon State College	La Grande
	Oregon College of Education	Monmouth
	Oregon Institute of Technology	Klamath Falls
	Oregon State University	Corvallis
	Portland State University	Portland
	Southern Oregon State College	Ashland
	University of Oregon-Health Sciences Center	Portland
	Pacific University	Forest Grove
	Reed College	Portland
	Southwestern Oregon Community College	Coos Bay
	Treasure Valley Community College	Ontario
	Umpqua Community College	Rosenburg
	University of Portland	Portland
	Warner Pacific College	Portland
	Western Baptist Bible College	Salem
	Western Conservative Baptist Seminary	Portland
	Western Evangelical Seminary	Portland
	Williamette University	Salem
PA	Allegheny College	Meadville
	Allentown College of St. Francis De Sales	Center Valley
	Alliance College	Cambridge Springs
	Beaver College	Glenside
	Bloomsburg State College	Bloomsburg
	Bucks County Community College	Newton
	Butler County Community College	Butler
	Cabrini College	Radnor
	California State College	California
	Carlow College	Pittsburgh
	Carnegie-Mellon University	Pittsburgh
	Cedar Crest College	Allentown
	Chestnut Hill College	Philadelphia
	Cheyney State College	Cheyney
	Clarion State College	Clarion
	Community College of Allegheny County	Pittsburgh
	Community College of Beaver County	Monaca
	Community College of Philadelphia	Philadelphia
	Delaware Valley College of Science and Agriculture	Doylestown

APPENDIX V
CATALOGS REVIEWED

STATE	INSTITUTION	LOCATION
	Dickinson College	Carlisle
	Drexel University	Philadelphia
	The Dropsie University	Philadelphia
	Duquesne University	Pittsburgh
	Eastern College	Saint Davids
	East Stroudsburg State College	East Stroudsburg
	Edinboro State College	Edinboro
	Franklin-Marshall College	Lancaster
	Gannon College	Erie
	Geneva College	Beaver Falls
	Gettysburg College	Gettysburg
	Gwynedd-Mercy College	Gwynedd Valley
	Harcum Junior College	Bryn Mawr
	Haverford College	Haverford
	Indiana University of Pennsylvania	Indiana
	Juniata College	Huntingdon
	Keystone Junior College	La Plume
	King's College	Wilkes-Barre
	Lafayette College	Easton
	La Roche College	Allison Park
	La Salle College	Philadelphia
	Lehigh University	Bethlehem
	Lincoln University	Lincoln University
	Lock Haven State College	Lock Haven
	Lycoming College	Williamsport
	Mansfield State College	Mansfield
	Marywood College	Scranton
	Mercyhurst College	Erie
	Millersville State College	Millersville
	Montgomery County Community College	Blue Bell
	Northeastern Christian Junior College	Villanova
	Pennsylvania State University	University Park
	Philadelphia College of Pharmacy and Science	Philadelphia
	Point Park College	Pittsburgh
	Reading Area Community College	Reading
	Saint Fidelis College	Herman
	Saint Francis College	Loretto
	Saint Joseph's College	Philadelphia
	Saint Vincent College	Latrobe
	Seton Hill College	Greensburg
	Slippery Rock State College	Slippery Rock
	Spring Garden College	Chestnut Hill
	Susquehanna University	Selinsgrove
	Swarthmore College	Swarthmore
	Temple University	Philadelphia
	University of Pennsylvania	Philadelphia
	University of Pittsburg	Pittsburgh
	University of Scranton	Scranton
	Ursinus College	Collegeville
	Villa Maria College	Erie
	Villanova University	Villanova
	Waynesburg College	Waynesburg
	West Chester State College	West Chester
	Westminster College	New Wilmington
	Widener College	Chester
	Wilkes College	Wilkes-Barre
	Williamsport Area Community College	Williamsport
	Wilson College	Chambersburg
PR	Inter American University of Puerto Rico	San German
	The Catholic University of Puerto Rico	Ponce
	University of Puerto Rico	Mayaguez
	University of Puerto Rico	Rio Pedras

APPENDIX V

CATALOGS REVIEWED

STATE	INSTITUTION	LOCATION
RI	Brown University	Providence
	Providence College	Providence
	Roger Williams College	Bristol
	University of Rhode Island	Kingston
SC	Aiken Technical Education Center	Aiken
	Baptist College	Charleston
	Bob Jones University	Greenville
	Central Wesleyan College	Central
	Citadel Military College of South Carolina	Charleston
	Claflin College	Orangeburg
	Clemson University	Clemson
	Coastal Carolina College	Conway
	Coker College	Hartsville
	College of Charleston	Charleston
	Columbia College	Columbia
	Columbia Bible College	Columbia
	Converse College	Spartanburg
	Erskine College	Due West
	Florence-Darlington Technical College	Florence
	Francis Marion College	Florence
	Furman University	Greenville
	Greenville Technical College	Greenville
	Lander College	Greenwood
	Limestone College	Gaffney
	Morris College	Sumter
	Newberry College	Newberry
	North Greenville College	Tigerville
	Orangeburg-Calhoun Technical College	Orangeburg
	Piedmont Technical College	Greenwood
	South Carolina State College	Orangeburg
	Sumter Area Technical College	Sumter
	Tri County Technical College	Pendleton
	Trident Technical College	North Charleston
	University of South Carolina	Columbia
	University of South Carolina at Aiken	Aiken
	University of South Carolina at Beaufort	Beaufort
	University of South Carolina at Spartanburg	Spartanburg
	University of South Carolina at Union	Union
	Voorhees College	Denmark
	Winthrop College	Rock Hill
	Wofford College	Spartanburg
SD	Augustana College	Sioux Falls
	Black Hills State College	Spearfish
	Dakota Wesleyan University	Mitchell
	Freeman Junior College	Freeman
	National College of Business	Rapid City
	Northern State College	Aberdeen
	Presentation College	Aberdeen
	Sioux Falls College	Sioux Falls
	South Dakota School of Mines and Technology	Rapid City
	South Dakota State University	Brookings
	University of South Dakota-Springfield	Springfield
TN	Aquinas Junior College	Nashville
	Austin Peay State University	Clarksville
	Belmont College	Nashville
	Carson-Newman College	Jefferson City
	Chattanooga State Technical Community College	Chattanooga

APPENDIX V

CATALOGS REVIEWED

STATE	INSTITUTION	LOCATION
	Christian Brothers College	Memphis
	Cleveland State Community College	Cleveland
	Columbia State Community College	Columbia
	Covenant College	Lookout Mountain
	Cumberland College	Lebanon
	David Lipscomb College	Nashville
	Dyersburg State Community College	Dyersburg
	East Tennessee State University	Johnson City
	Fisk University	Nashville
	Freed-Hardeman College	Henderson
	Free Will Baptist Bible College	Nashville
	George Peabody College for Teachers	Nashville
	Hiwassee College	Madisonville
	Jackson State Community College	Jackson
	King College	Bristol
	Knoxville College	Knoxville
	Lambuth College	Jackson
	LeMoyne-Owen College	Memphis
	Martin College	Pulaski
	Memphis State University	Memphis
	Middle Tennessee State University	Murfreesboro
	Milligan College	Milligan College
	Nashville State Technical Institute	Nashville
	Roane State Community College	Harriman
	Shelby State Community College	Memphis
	State Technical Institute at Memphis	Memphis
	Steed College	Johnson City
	Tennessee Technological University	Cookeville
	Tennessee Wesleyan College	Athens
	University of the South	Sewanee
	University of Tennessee	Knoxville
	University of Tennessee Center for Health Sciences	Memphis
	University of Tennessee at Martin	Martin
	University of Tennessee at Nashville	Nashville
	Vanderbilt University	Nashville
	Volunteer State Community College	Gallatin
	Walters State Community College	Morristown
TX	Abilene Christian University	Abilene
	Alvin Community College	Alvin
	Amarillo College	Amarillo
	American Technological University	Killeen
	Angelina College	Lufkin
	Angelo State University	San Angelo
	Austin College	Sherman
	Austin Presbyterian Technological Seminary	Austin
	Baylor College of Dentistry	Dallas
	Baylor College of Medicine	Houston
	Baylor University	Waco
	Bee County College	Beeville
	Blinn College	Brenham
	Brazosport College	Lake Jackson
	Cisco Junior College	Cisco
	Clarendon College	Clarendon
	College of the Mainland	Texas City
	Concordia Lutheran College	Austin
	Cooke County College	Gainesville
	Dallas Bible College	Dallas
	Dallas Christian College	Dallas
	Dallas County Community College District	
	Eastfield College	Mesquite
	El Centro College	Dallas
	Mountain View College	Dallas
	Richland College	Dallas

APPENDIX V

CATALOGS REVIEWED

STATE	INSTITUTION	LOCATION
	Dallas Theological Seminary	Dallas
	Del Mar College	Corpus Christi
	DeVry Institute of Technology	Dallas
	East Texas Baptist College	Marshall
	East Texas State University	Commerce
	El Paso Community College	El Paso
	Frank Phillips College	Borger
	Galveston College	Galveston
	Grayson College	Denison
	Gulf Coast Bible College	Houston
	Hardin-Simmons University	Abilene
	Henderson County Junior College	Athens
	Houston Baptist University	Houston
	Houston Community College	Houston
	Howard College at Big Spring	Big Spring
	Howard Payne University	Brownwood
	Huston-Tillotson College	Austin
	Incarnate Word College	San Antonio
	Jacksonville College	Jacksonville
	Jarvis Christian College	Hawkins
	Kilgore College	Kilgore
	Lamar University	Beaumont
	Laredo Junior College	Laredo
	Lee College	Baytown
	Le Tourneau College	Longview
	Lon Morris College	Jacksonville
	Lubbock Christian College	Lubbock
	McLennan Community College	Waco
	McMurry College	Abilene
	Midland College	Midland
	Midwestern State University	Wichita Falls
	Navarro College	Corsicana
	North Harris County College	Houston
	North Texas State University	Denton
	Odessa College	Odessa
	Our Lady of the Lake University of San Antonio	San Antonio
	Pan American University	Edinburg
	Panola Junior College	Carthage
	Ranger Junior College	Ranger
	Rice University	Houston
	Saint Edward's University	Austin
	Sam Houston State University	Huntsville
	San Antonio College	San Antonio
	San Jacinto College	Pasadena
	Schreiner College	Kerrville
	Southern Bible College	Houston
	Southern Methodist University	Dallas
	South Plains College	Levelland
	South Texas College of Law	Houston
	Southwestern Assemblies of God College	Waxahachie
	Southwestern Baptist Theological Seminary	Fort Worth
	Southwestern Christian College	Terrell
	Southwestern Union College	Keene
	Southwestern University	Georgetown
	Southwest Texas State University	San Marcos
	Stephen F. Austin State University	Nacogdoches
	Tarleton State University	Stephenville
	Tarrant County Junior College-Northeast Campus	Hurst
	Tarrant County Junior College-Northwest Campus	Fort Worth
	Tarrant County Junior College-South Campus	Fort Worth
	Texarkana College	Texarkana
	Texas A & I University	Kingsville

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CATALOGS REVIEWED

STATE	INSTITUTION	LOCATION
	Texas A & I University-Corpus Christi	Corpus Christi
	Texas A & I University-Laredo	Laredo
	Texas A & M University-Main Campus	College Station
	Texas A & M University Moody College of Marine Sciences and Maritime Resources	Galveston
	Texas Christian University	Fort Worth
	Texas College	Tyler
	Texas Lutheran College	Seguin
	Texas Southmost College	Brownsville
	Texas State Technical Institute-James Connally Campus	Waco
	Texas State Technical Institute-Mid-Continent Campus	Amarillo
	Texas State Technical Institute-Rio Grande Campus	Harlingen
	Texas Tech University	Lubbock
	Texas Wesleyan College	Fort Worth
	Texas Woman's University	Denton
	Trinity University	San Antonio
	Tyler Junior College	Tyler
	University of Dallas	Irving
	University of Houston-Main Campus	Houston
	University of Houston-Clear Lake City	Houston
	University of Houston-Victoria Campus	Victoria
	University of Texas-Arlington	Arlington
	University of Texas-Austin	Austin
	University of Texas at Dallas	Richardson
	University of Texas-El Paso	El Paso
	University of Texas Health Science Center at Dallas	Dallas
	University of Texas Health Science Center at Houston	Houston
	University of Texas Medical Branch at Galveston	Galveston
	University of Texas-San Antonio	San Antonio
	Vernon Regional Junior College	Vernon
	Victoria College	Victoria
	Weatherford College	Weatherford
	Western Texas College	Snyder
	West Texas State Universtiy	Canyon
	Wharton County Junior College	Wharton
	Wiley College	Marshall
UT	Brigham Young University	Provo
	Stevens Henager College	Ogden
	University of Utah	Salt Lake City
	Utah Higher Education System Office	
	University of Utah	Salt Lake City
	Utah State University	Logan
	Southern Utah State College	Cedar City
	Weber State College	Ogden
	College of Eastern Utah	Price
	Dixie College	Saint George
	Snow College	Ephraim
	Utah Technical College at Salt Lake City	Salt Lake City
	Westminster College	Salt Lake City

APPENDIX V

CATALOGS REVIEWED

STATE	INSTITUTION	LOCATION
VT	Champlain College	Burlington
	Johnson State College	Johnson
	Lyndon State College	Lyndonville
	Marlboro College	Marlboro
	Middlebury College	Middlebury
	Norwich University	Northfield
	Saint Michael's College	Winooski
	School for International Training	Brattleboro
	Southern Vermont College	Bennington
	Trinity College	Burlington
	University of Vermont and State Agriculture College	Burlington
	Vermont Institute of Community Involvement	South Burlington
	Vermont Technical College	Randolph Center
	Windham College	Putney
VA	Averett College	Danville
	Bridgewater College	Bridgewater
	College of William and Mary	Williamsburg
	Eastern Mennonite College	Harrisonburg
	Eastern Virginia Medical School	Norfolk
	Emory and Henry College	Emory
	Ferrum College	Ferrum
	Hampton Institute	Hampton
	Institute of Textile Technology	Charlottesville
	J. Sargeant Reynolds Community College	Richmond
	Madison University	Harrisonburg
	Old Dominion University	Norfolk
	Radford College	Radford
	Randolph-Macon College	Ashland
	Randolph-Macon Woman's College	Lynchburg
	Saint Paul's College	Lawrenceville
	University of Virginia	Charlottesville
	Virginia Intermont College	Bristol
	Virginia Military Institute	Lexington
	Virginia Polytechnic Institute and State University	Blacksburg
	Virginia Wesleyan College	Norfolk
	Washington and Lee University	Lexington
	Wytheville Community College	Wytheville
WA	Bellevue Community College	Bellevue
	Big Bend Community College	Moses Lake
	Centralia College	Centralia
	Central Washington State College	Ellensburg
	Clark College	Vancouver
	Columbia Basin Community College	Pasco
	Cornish School of Allied Arts	Seattle
	Eastern Washington State College	Cheney
	Evergreen State College	Olympia
	Fort Steilacoom Community College	Tacoma
	Fort Wright College of the Holy Names	Spokane
	Gonzaga University	Spokane
	Grays Harbor College	Aberdeen
	Green River Community College	Auburn
	Highline Community College	Midway
	Lower Columbia College	Longview
	Lutheran Bible Institute of Seattle	Seattle
	Northwest College of the Assemblies of God	Kirkland
	Olympia Technical Community College	Olympia
	Olympic College	Bremerton
	Pacific Lutheran University	Tacoma
	Peninsula College	Port Angeles

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CATALOGS REVIEWED

STATE	INSTITUTION	LOCATION
	Seattle Community College District	
	North Seattle Community College	Seattle
	Seattle Community College-Central Campus	Seattle
	Seattle Community College-South Campus	Seattle
	Seattle University	Seattle
	Shoreline Community College	Seattle
	Skagit Valley College	Mount Vernon
	Tacoma Community College	Tacoma
	University of Puget Sound	Tacoma
	Walla Walla College	College Place
	Walla Walla Community College	Walla Walla
	Washington State Community College-District 5	
	Edmonds Community College	Lynnwood
	Everett Community College	Everett
	Washington State Community College-District 17	
	Spokane Falls Community College	Spokane
	Washington State University	Pullman
	Wenatchee Valley College	Wenatchee
	Western Washington State College	Bellingham
	Whatcom Community College	Bellingham
	Whitman College	Walla Walla
	Whitworth College	Spokane
	Yakima Valley College	Yakima
WV	Alderson Broaddus College	Phillippi
	Beckley College	Beckley
	Bethany College	Bethany
	Bluefield State College	Bluefield
	Concord College	Athens
	Davis and Elkins College	Elkins
	Glenville State College	Glenville
	Marshall University	Huntington
	Morris Harvey College	Charleston
	Parkersburg Community College	Parkersburg
	Potomac State College	Keyser
	Salem College	Salem
	West Liberty State College	West Liberty
	West Virginia Institute of Technology	Montgomery
	West Virginia University	Morgantown
	Wheeling College	Wheeling
WI	Alverno College	Milwaukee
	Beloit College	Beloit
	Blackhawk Technical Institute	Janesville
	Cardinal Stritch College	Milwaukee
	Carroll College	Waukesha
	Carthage College	Kenosha
	Concordia College	Milwaukee
	District One Technical Institute	Eau Claire
	Edgewood College	Madison
	Fox Valley Technical Institute	Appleton
	Gateway Technical Institute	Kenosha
	Holy Redeemer College	Waterford
	Institute of Paper Chemistry	Appleton
	Lakeshore Technical Institute	Cleveland
	Lawrence University	Appleton
	Madison Area Technical College	Madison
	Madison Business College	Madison
	Marian College of Fond Du Lac	Fond Du Lac
	Marquette University	Milwaukee
	Mid-State Technical Institute	Wisconsin Rapids
	Milton College	Milton

APPENDIX V

CATALOGS REVIEWED

STATE	INSTITUTION	LOCATION
	Milwaukee Area Technical College	Milwaukee
	Moraine Park Vocational, Technical and Adult Education Institute	Fond Du Lac
	Mount Mary College	Milwaukee
	Mount Senario College	Ladysmith
	Nicolet College and Technical Institute	Rhinelander
	North Central Technical Institute	Wausau
	Northeast Wisconsin Technical Institute	Green Bay
	Northland College	Ashland
	Ripon College	Ripon
	Saint Norbert College	De Pere
	Silver Lake College	Manitowoc
	Southwest Wisconsin Vocational-Technical Institute	Fennimore
	University of Wisconsin-Green Bay	Green Bay
	University of Wisconsin-Madison	Madison
	University of Wisconsin-Milwaukee	Milwaukee
	University of Wisconsin-System Office	Madison
	Viterbo College	La Crosse
	Waukesha County Technical Institute	Pewaukee
	Western Wisconsin Technical Institute	La Crosse
WY	Casper College	Casper
	Eastern Wyoming College	Torrington
	Laramie County Community College	Cheyenne
	Northwest Community College	Powell
	Sheridan College	Sheridan
	University of Wyoming	Laramie
	Western Wyoming Community College	Rock Springs